DEFENCE R&D DÉFENSE

Defence Research and Development

Annual Report

1999 · 2000

Canada

Foreword

I am pleased to present the second Annual Report of the Defence Research and Development Branch (DRDB), covering the Branch's activities during fiscal year 1999/2000. This document is a significant milestone in the evolution of our organization, since it covers the last year of our operation as a Branch within the Materiel Group of the Department of National Defence (DND). On 1 April 2000, DRDB became an Agency and Level 1 organization within DND, with the new name of Defence R&D Canada (DRDC).

Agency status provides opportunities for change that will help us respond to the needs of DND and the Canadian Forces in a rapidly evolving environment. New business processes and innovative approaches to management of science and technology will help us to create centres of excellence in niche areas of defence research and development. We will use our new structure to enhance our core competencies, develop new technologies, enter into diverse partnerships and increase the efficiencies of our operations.

This report is a critical element in our accountability framework. Its purpose is to show our clients how well we have performed relative to the targets set out in our Business Plan and Service Level Agreements, using a combination of quantitative data and qualitative information. Its preparation has been influenced significantly by the Branch's conversion to an Agency and our associated commitment to operate in a more business-like manner.

The success of an R&D organization depends fundamentally on the competence, dedication and diligence of its people. I commend DRDC's staff for their excellent performance during the past year, which saw the launch of many initiatives within the organization, with associated demands on staff time and attention.

I also extend my sincere appreciation to our clients for their active involvement in our R&D programs and for their co-operation and assistance in establishing the Agency. We have set ambitious targets for DRDC over its first five years, including increases in our R&D capacity and productivity, and provision of more R&D to DND and the Canadian Forces for the same investment. We are taking the initiatives needed to meet these targets, and we are confident that we will achieve our goals.

L.J. Leggat
Chief Research and Development

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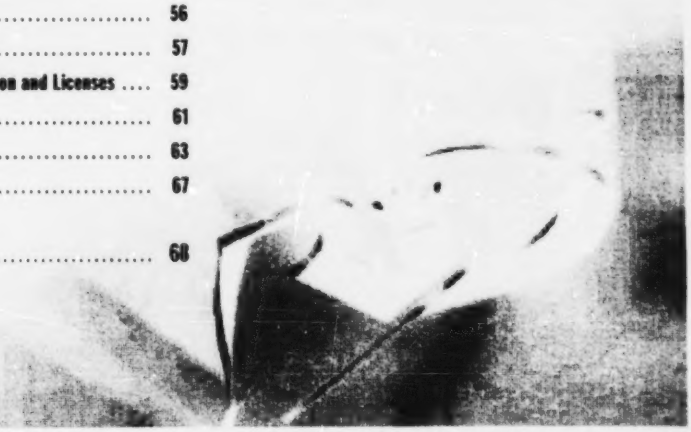

Our Vision

As Canada's lead defence science and technology (S&T) organization, the vision of Defence R&D Canada is to provide S&T leadership to the Department, the Canadian Forces and the Canadian defence industrial base through the 21st century.

Our Mission

The mission of Defence R&D Canada is to:

- Facilitate and enhance the ability of decision makers to make informed decisions on defence policy, force generation, and procurement by providing expert S&T knowledge;
- Contribute to the success of military operations by pursuing R&D activities that provide improved support, knowledge, protection, and response to potential threats;
- Enhance the preparedness of the Canadian Forces by assessing technology trends, threats and opportunities, and by exploiting emerging technologies;
- Contribute to the creation and maintenance of a Canadian defence S&T industrial capability that is internationally competitive, by contracting-out to industry, by transferring technology to industry and by entering into partnerships in which cost and risk are shared; and
- Conduct S&T projects for clients external to DND, in order to assist the Agency in developing and maintaining its defence-related technological capabilities.

1 Branch Overview

AS NOTED IN THE FOREWORD, ON 1 APRIL 2000 THE DEFENCE RESEARCH AND DEVELOPMENT BRANCH (DRDB) BECAME AN AGENCY AND LEVEL 1 ORGANIZATION WITHIN DND, WITH THE NEW NAME OF DEFENCE R&D CANADA (DRDC). THUS, THIS REPORT COVERS OUR ORGANIZATION'S LAST YEAR OF OPERATION AS A BRANCH WITHIN THE MATERIEL GROUP. THE READER WILL FIND HEREIN REFERENCE TO BOTH DRDB AND DRDC – DRDB WHEN WE ARE LOOKING AT THE PAST AND DRDC WHEN WE ARE CONSIDERING THE PRESENT AND THE FUTURE.

Defence R&D Canada consists of a headquarters, located in Ottawa, and five Defence Research Establishments (DREs):

- Defence Research Establishment Atlantic (DREA), in Halifax, performs R&D in undersea warfare, naval platform technology and naval command and control.
- Defence Research Establishment Valcartier (DREV), near Quebec City, is the main centre for R&D related to weapon systems, electro-optics and command and control information systems.
- Defence Research Establishment Ottawa (DREO) is responsible for R&D in electronic warfare, radar, space systems and telecommunications.
- Defence and Civil Institute of Environmental Medicine (DCIEM), in Toronto, conducts R&D in human performance, human-systems integration, simulation and training, military operational medicine, and life support systems.
- Defence Research Establishment Suffield (DRES), in south-eastern Alberta, carries out R&D in chemical and biological defence, military engineering and tactical vehicle systems.

Table 1 provides further detail on the scientific capabilities of the DREs. Table 2 gives a resource summary for the organization. Table 3 lists the R&D activities that DRDC is pursuing.

The Agency delivers services along four Business Lines.

(1) R&D for the Canadian Forces and DND

The majority of the Agency's resources are directed to this Business Line where most of its R&D activities take place. Activities within this Business Line are defined annually by Service Level Agreements (SLAs) with each of the Agency's major CF Client Groups. Elements of this Business Line include: Technology Investigation projects, Technology Application projects, the Technology

The Agency delivers services along four Business Lines.

Demonstration Program, the Technology Investment Fund, the Defence Industrial Research Program, the DND/NSERC Research Program, and the Defence Communications Program. These are defined in Annex A.

(2) Strategic S&T Policy and Advice

This Business Line includes the strategic studies, advice and input to policy that the Agency provides to senior decision-makers in the Department and the CF on S&T issues. It also includes research in support of scientific and technical intelligence and technology watch/outreach activities.

(3) S&T with National Security Partners

This Business Line enables the Agency to exploit its S&T base to serve the needs of clients outside DND, including Canadian industry and other government departments. Also under this Business Line, the Agency may conduct projects for DND clients not covered by Business Lines 1 and 2. Under Business Line 3, the Agency collects and retains revenues to assist the development and maintenance of its technological capabilities.

(4) Corporate Management

This Business Line includes central administration, infrastructure, human resources and management overhead. It also includes business planning, notably the formulation of the R&D programs for the Agency's major CF Client Groups, as well as management and co-ordination of international activities.

The R&D programs in Business Lines 1 and 2 are delivered via a structure of 28 R&D Thrusts (25 in Business Line 1 and 3 in Business Line 2). They are listed in Table 4, along with their fundamental objectives. Estimated resources by Client Group and Thrust are given in Table 5.

This report is concerned with DRDB's performance in fiscal year 1999/2000. It begins by highlighting major achievements. Progress is then noted on Key Objectives that were formulated in 1998. Next, the Branch's performance in program delivery is assessed, under each of the above-noted Business Lines. Thus, we begin with Business Line 1 – the R&D programs for our five Client Groups – using such information and metrics as progress on major initiatives and success rate in delivery against agreed milestones. The following three chapters are concerned with our other three Business Lines. Next, collaboration with international partners is discussed, followed by presentation of indicators of excellence in science. The report concludes with some observations on our performance in 1999/2000.

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2 Highlights

WE SHALL BEGIN BY DESCRIBING SOME OF THE MAJOR ACHIEVEMENTS ARISING FROM THE R&D PROGRAMS FOR OUR FIVE CLIENT GROUPS. NOTE THAT WE HAVE ARBITRARILY RESTRICTED OURSELVES HEREIN TO TEN HIGHLIGHTS FOR EACH CLIENT GROUP. WE CONCLUDE THIS CHAPTER WITH SOME CORPORATE HIGHLIGHTS.

Maritime Program

Integration of an Advanced ESM Receiver with Radar and Navigation Units

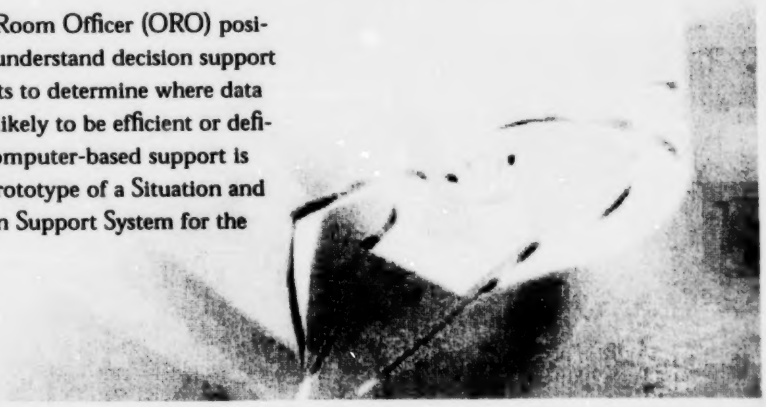
A novel multi-function, multi-channel digital receiver, which can measure simultaneously the intrapulse information and high accuracy direction-finding on radar emitters, has been developed in-house. This prototype receiver, covering both the X- and S-navigation frequency bands and using commercial components, has been integrated with a navigation radar, a global positioning system and an inertial navigation system. This prototype system has been successfully field tested on a number of flights on board a Convair 580 aircraft and onshore against ship-borne targets.

SHIPIR/NTCS Accredited as NATO Standard Model

At the final meeting of the NATO Technical Group on Infrared Measurements and Modelling for Ship Self Defence in October 1999, the Canadian Infrared Ship Signature and Ship Engagement Model, SHIPIR/NTCS, was officially recognised as the NATO Standard IR Ship Model. This accreditation was the result of a collective effort in which member countries (notably US, Germany, Italy, Canada, Netherlands and France) provided both human and financial resources to improve and validate the model. More than twenty international organisations (government and private sector) have purchased the model. TRUMP and Halifax Class infrared models have been created and input in SHIPIR/NTCS. Although dedicated ship trials are still needed, the level of confidence is good. The Navy has been using the model for a few years to improve TRUMP and Halifax Class IR signatures.

Cognitive Engineering Analysis

Cognitive engineering analysis for the Operations Room Officer (ORO) position of the Halifax Class was carried out to better understand decision support requirements. The analysis enables defence scientists to determine where data fusion and resource management technologies are likely to be efficient or deficient, and to identify specific areas where other computer-based support is needed. This will help to develop a first research prototype of a Situation and Threat Assessment/Resource Management Decision Support System for the ORO of the Halifax Class.



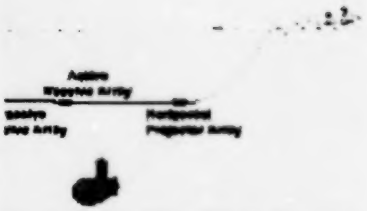
The ASCACT project has successfully developed a testbed for laboratory evaluation of real-time Multi-Source Data Fusion (MSDF) algorithms.

Advanced Shipboard Command and Control Technology (ASCACT) Project Nears Completion

The ASCACT project has successfully developed a testbed for laboratory evaluation of real-time Multi-Source Data Fusion (MSDF) algorithms. Real-time, at-sea data from the CCS 330 (the Halifax Class combat system) were also collected, in order to provide a baseline to assess the performance of MSDF algorithms relative to the performance of operators using the CCS 330. The ASCACT results will be of great value as the technical foundation for the Command Decision Aid Technology (COMDAT) project.

Towed Integrated Active Passive Sonar (TIAPS) Project Achieves Key Milestones

With CFAV Quest back from refit, the TIAPS project was able to conduct the first of a series of sea trials to demonstrate increasingly more complete low frequency acoustic (LFA) systems. The goal of this trial was to evaluate the performance of a 32-element Horizontal Projector Array (HPA) utilizing pressure-compensated barrel stave projectors. The HPA is one of two candidate systems for providing the low-frequency active source, the other being a vertical array of two free-flooding ring projectors. The trial was successfully completed in February 2000, although problems with depth-sensing gauges in the array prevented deployment of the array at maximum depth. Another important milestone was achieved with the awarding of a major dry-end contract to Computing Devices Canada (CDC). CDC will contribute $1M toward this project.



A sea trial was conducted to evaluate a Horizontal Projector Array for the Towed Integrated Active Passive Sonar project

Airborne Sonar Systems Achieve Trials Success

- The fourth in a series of very successful international multi-static LFA trials involving DRDC's IMPACT (Integrated Multi-static Passive-Active Concept Testbed) system was held off the coast of Oregon in September 1999. Detection results were gratifying despite the use of a difficult target (small diesel-electric submarine) in an adverse ocean environment (downward refracting conditions in shallow water).
- With the completion of the WASS (Wide-Area Subsurface Surveillance) airborne sonar system (based largely on IMPACT functionality) for the Aurora maritime patrol aircraft (MPA), the focus has moved to using WASS in free-play scenarios to advance tactical development. The first in a planned series of such trials took place off Hawaii in February 2000 and demonstrated again the effectiveness of multi-static LFA sonar.
- DREA developed and successfully demonstrated a novel command and data relay system using low earth orbit communications satellites to link a sonobuoy with a command and processing system on shore. During one

demonstration, the command team in Winnipeg 'called up' an active sonobuoy deployed in the Gulf of Mexico, commanded it to ping, and then recorded, analysed and displayed the acoustic signals. This capability would be very useful for long-term surveillance in areas where it would be impossible to maintain air assets on station.

Compact LUCIE under Development

Based on the unique and extensive expertise gathered with the original LUCIE (Laser Underwater Camera and Image Enhancer) in the mid 1990s, a new design for a very compact range-gated underwater camera with improved illumination has been completed. The main components have been purchased, and preliminary assembly has started. Talks are in progress with SATLANTIC of Halifax to transfer this technology to industry. The device is expected to be available for tests in Halifax by the end of summer 2000.

Dorado Demonstration Conducted in France

For the past four years, DRDB has been developing the Dorado semi-submersible unmanned vehicle (SUV) based on technology developed in the early 1980s for oceanographic surveys. Dorado's many modifications and enhancements enable it to be a testbed for the Remote Mine-hunting System (RMS) technology demonstration for the Canadian Navy. Dorado's capabilities were demonstrated in a trial near Brest, France in 1999. In the trial, Dorado towed a multi-beam side scan sonar at 10 knots in varying water depths, transmitting and displaying the sonar data to an operator on the command ship in real time, and provided tow vehicle positions for accurately relocating identified targets. The trial was a complete success. Dorado recorded over 10 Gb of sonar data, completed a 70 km transit to deep water, towed the sonar at 100 m depth, and underwent acoustic and magnetic ranging. On the final two days of the trial, the system was demonstrated to the French Navy and representatives from 17 other countries.

Dorado SUV on mine-hunting demonstration trials for the French Navy

Dynamic Stability Criteria

Canada is working to develop new ship stability criteria with navies from Australia, France, the Netherlands, UK and US. The new stability criteria will incorporate a more realistic treatment of the physics of ship capsize. A numerical model has been developed for simulation of intact and damaged frigates in waves. Canada has developed a capsize risk analysis procedure which will form the basis for new intact stability criteria for the participating navies. A simulation study has examined the influence of proposed modifications on damage stability behaviour for the TRUMP class. Ongoing work is improving the accuracy and visualization capabilities for simulations of damaged ships in waves. The project will ultimately deliver a comprehensive simulation capability

and stability criteria for both intact and damaged ships in waves. Benefits of this work will include more consistent safety levels for CF ships, operational guidelines for avoiding conditions likely to cause capsize, and possibly greater flexibility in placing equipment on ships.

Air Independent Propulsion (AIP) Model Testing Successfully Completed

Advances in fuel cell technology made as a result of Development Project "Fuel Cell Centred Air Independent Power" have successfully demonstrated the feasibility of integrating a reduced-scale fuel cell power plant into a submarine. The issues associated with storage of hydrogen have been overcome through the catalytic conversion of methanol into a hydrogen-rich fuel. The exploratory development model has been tested for over 450 hours, achieving 60KW at 50% efficiency. AIP has the potential to greatly increase the operational capability of conventional submarines by substantially increasing submerged endurance.

Land Program

Light Support Wheeled Vehicle Landmine Protection

Protection of vehicle occupants from the effects of landmines is a serious concern in peacekeeping missions. The occupants of lightweight civilian pattern vehicles are particularly vulnerable. In recent work at DRES, the effects of landmine blast were modelled extensively with supporting experimentation, in order to design structures to withstand the mine blast and protect the vehicle occupants. A significant breakthrough in landmine protection was achieved at DREV and demonstrated in the summer of 1999. A vehicle was modified by raising the cab 15 cm, installing blast deflectors and strengthening the cab. The vehicle was subjected to a 4 kg blast, and mannequins wearing diagnostic instrumentation proved that human occupants could have survived the event. This was four times the previously demonstrated protection level for that vehicle.

FIXOR – Replacement for C4 in Landmine Neutralization

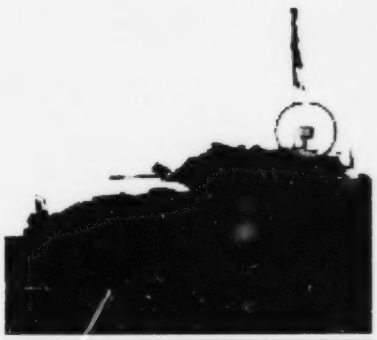
C4 plastic explosive is commonly used to destroy landmines and other unexploded ordnance in demining and range clearance operations. However, C4 is expensive and may not be readily available for demining operations in theatres such as Kosovo, because of purchase and shipping restrictions. DRDC has assisted Mining Resources Engineering of Kingston to develop a replacement for C4. This new product, known as the Field-friendly Inexpensive Unexploded Ordnance Remover or FIXOR™, is a two-part

mixture of a flammable liquid and an inert powder. When the powder and liquid are mixed, the resulting mixture becomes cap sensitive. Prior to mixing, FIXOR is classified as a Class 2 flammable liquid and, unlike C4, can be shipped globally by commercial carrier. Moreover, FIXOR is about half the cost of C4. DRES successfully tested FIXOR against anti-tank and anti-personnel mines, as well as ordnance up to 105mm. The Directorate of Ammunition Program Management is considering acquiring FIXOR for military engineering use on overseas missions.

The Australian Army adopted the EBB, an integrated suite of user-friendly tools on a CD-ROM, to reduce the planning time for military operations.

Electronic Battle Box

Following a review of off-the-shelf decision-aid tools, the Australian Army adopted the Canadian Electronic Battle Box (EBB) for its Tactical Battlefield Support System. Distributed on CD-ROM, the EBB is an integrated suite of efficient and user-friendly tools that significantly reduce the planning time for military operations. It is the result of a collaborative effort between DREV, the Directorate of Army Doctrine, the Directorate of Land Requirements, the logistics staff of 1Canadian Division HQ, and CGI Information and Management Consultants Inc. Among the tools are: an Order of Battle Browser and an Equipment Browser for viewing and editing military organizations, a Task Browser providing facilities to prepare plans using Gantt charts, a Logistic Planner for estimating supply requirements, and Road, Air and Rail Movement Planners. EBB also provides staff officers with a large set of doctrinal documents in an electronic format.



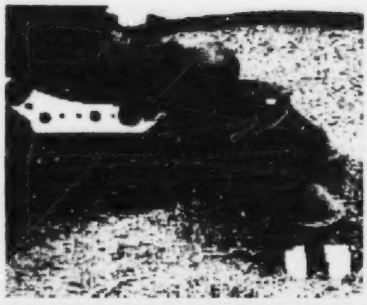
Coyote reconnaissance vehicle with Defensive Aid Suite

Soldier Information Requirements (SIREQ)

The aim of this project is to understand the information needs of the dismounted soldier and develop tools, techniques, concepts and prototypes for systems and operator/machine interfaces for improved command and control at the sub-unit level. The project successfully identified the soldier's key cognitive tasks in three dismounted-infantry section-level tactical scenarios that could be improved through information enhancement. It also identified the methods of information enhancement and refined the human factors tools required. This project has made an essential contribution to the successful refocusing of the Integrated Protective Clothing and Equipment Technology Demonstration.

Defensive Aids Suite Trial

Canada hosted a major TTCP trial (Trial Pronghorn) at CFB Gagetown in October 1999 to explore the effectiveness of developmental Defensive Aids Suites (DAS) for light armoured vehicles. Four DAS systems were tested: one each from Canada and the UK, and two from the US. The DAS systems were mounted on Canadian Coyote vehicles and featured: laser warning receivers to detect laser range finders or laser beam rider missiles; a processing and display



A radically new foot protection system has been developed for demining operations

unit; and countermeasures, primarily the deployment of screening smoke. The Canadian system also featured the ability to slave the turret to the direction of the laser to return fire. The Canadian system was developed in a partnership between DRDC and a consortium headed by Litton Systems of Canada, with the consortium paying 75% of the development costs. The main feature of the Canadian DAS is the integration of the world-recognized HARLID (High Angle Resolution Laser Illumination Detector) technology developed at DREV and licensed to Perkin-Elmer of Vaudreuil. The Canadian system was the most highly integrated of the DAS systems tested and proved to be the most effective in the trial.

Electronic Thermal Neutron Activation (TNA)

In 1998 DRDC delivered a multi-sensor vehicle-mounted mine detection system in support of Development Project "Improved Landmine Detection Capability". Unique to this system is a confirmatory sensor based on TNA that detects concentrations of nitrogen found in explosives. The original TNA used a radioactive source, which is unattractive because of the difficulties in transporting and licensing the radioactive material, as well as the potential for contamination in the event of an accident. During the past year, DREO and DRES, with the support of the Directorate of Field Support Equipment Program Management, developed a substitute electronic source which offers faster detection and can be transported, maintained and stored without the constraints imposed by the radioactive source.

Foot Protection System and Humanitarian Demining Ensemble

With technical and financial support from DRDC, MedEng Systems of Ottawa has developed improved protective boots and suits for personnel exposed to the dangers of landmines. In the case of the boot, MedEng has developed a radically new foot protection system that provides protection against anti-personnel mines with 100 g of explosive. The protection is achieved by elevating the foot and deflecting the blast from the mine, thus reducing the transfer of momentum to the leg of the wearer. As to the mine suit, the CF currently uses the MedEng MCS4 suit to protect soldiers during mine clearing operations. These suits are heavy, inflexible, and hot. With the support of the Canadian Centre for Mine Action Technologies (CCMAT), MedEng has developed a lighter demining suit, called the Humanitarian Demining Ensemble (HDE), that offers basic protection against mine blast to the frontal torso, face, head, ears and hands. The HDE weighs 17 kg, as compared to 33 kg for the MCS4, and is open in the back, thus offering better flexibility and cooling.

Landmine Tripwire Detection

Tripwire activated mines form a portion of most landmine threat profiles. Currently, soldiers find tripwires manually using tripwire feelers. Under a DIR contract with ITRES Research of Calgary, a feasibility study was completed that determined that hyper-spectral imaging might play a significant role in stand-off tripwire detection. The ITRES hyper-spectral imager is a passive sensor that compares the spectra reflected by various tripwire materials with background spectra from vegetation and soils. Conventional wire detectors need 5-10 m of wire to work, whereas the hyper-spectral imager can detect as little as 2 cm of wire. A demonstration unit is funded by CCMAT.

BioSteel™

Under a DIR contract, Nexia Biotechnologies of Montreal has successfully demonstrated all the stages necessary for large-scale production of silk proteins in the milk of transgenic mice and goats. The latest tensile tests indicate that silk being produced from the second generation of BioSteel™ genes has mechanical properties that are beginning to approach man-made high strength fibres. There is every reason to believe that the properties obtained will continue to improve with future generations of BioSteel™.

Canadian-American Critical Technologies for Unmanned Systems (CACTUS)

A collaborative project was undertaken by DRDC and the US Army Missile and Aviation Command to assess the potential of a Canadian 360 degree panospheric imaging (PI) system for remote driving, situational awareness, targeting, sensor fusion with acoustics and moving target indication. The project involved a comparative evaluation and demonstration of the effectiveness of the Canadian PI system and a conventional American multi-camera, pan-and-tilt video sensor, combined with a laser range finder. Joint testing was carried out using a Canadian electric-drive unmanned vehicle, the US Sarge unmanned vehicle, and the US HMMVW unmanned ground vehicle test bed. Both the Canadian and American sensor packages were tested on each unmanned vehicle to allow a full comparison by both nations. The trials, held in Huntsville, Alabama and Suffield, Alberta, offered the two organizations a unique opportunity to examine each other's approaches to sensing for unmanned ground vehicles, control station development, and unmanned vehicle platforms. Significantly more data were gathered than would have been possible without collaboration.

Air Program

Pyrophoric Decoy Flares

Under DRDC leadership, industry completed the advanced development of two variants of a new decoy flare, based on DREV's liquid pyrophoric technology. The new flares are designed to protect the CC-130 and CF-188 aircraft from modern IR seeking missiles. Approximately 1000 flares, fabricated using industrial processes, were successfully subjected to a rigorous qualification program. The program culminated in successful operational evaluation trials, held at Cold Lake, Alberta in October-November 1999. In these trials, a ground-based seeker test facility was used which DREV developed to remedy a national deficiency to measure vulnerability of air assets to IR threats. At the request of 1 Canadian Air Division (CAD), DREV also used this facility to support the evaluation of in-service flares in various operational scenarios. In January 2000, the acquisition of an operational stock of 5000 pyrophoric flares received approval. Considerable international interest has been shown in the flares.

Future Short–Range Air-To-Air Missiles

DREV provided technical assistance to the Directorate of Air Requirements in this subject area, contributing to the departmental recommendation to continue with the IRIS-T development program with European partners. Specifically, DREV led a three-year R&D examination of the performance of contender missiles for the CF-18 short-range requirement. The analysis produced envelopes of maximum-minimum range of each contender missile based upon detailed derived knowledge of the motor, seeker and airframe.

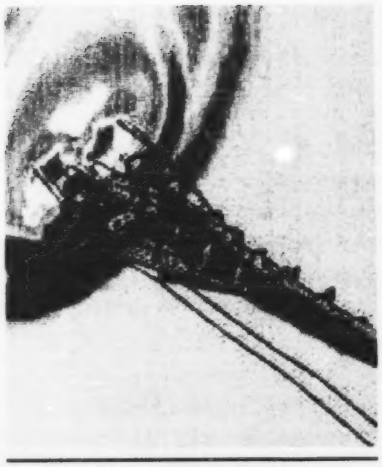
Heads-Up Display (HUD) for the Griffon Helicopter Night Vision Goggle (NVG)

DRDC used leading edge flight simulation tools to test a prospective system. The Griffon project office contacted DRDC Air Staff with a proposal to build on expertise from recent helmet-mounted display R&D projects. DRDC contracted Carleton University and BAE Systems to conduct the test. The initial design proved unsuitable to modern Griffon operations. DRDC assisted personnel from the operational test and evaluation flight at CFB Gagetown in a full re-design project. The new design will go into service with the fleet.

Flight Dynamics

- The Institute for Aerospace Research (IAR) used advanced modelling and simulation techniques to predict the flight dynamics of the new US JDAM munition launched from a CF-18. The results closely matched experiment, suggesting that in the future it will be possible to use these methods to reduce the cost of wind-tunnel and flight testing.

- IAR completed a study and facility to examine the safety of helicopter deck landings on CF frigates. The work, conducted in collaboration with the international community, has defined standard manoeuvres that a helicopter must be able to perform in order to land on a heaving deck in a wind.
- A new mathematical model has been produced to improve fidelity of CF-18 simulators in the high-angle-of-attack flight regime. The model is available to incorporate into training simulators.



Simulation of body and wing vortices on a missile using computational fluid dynamics

Avionics Simulation

DREO demonstrated a leading edge simulation of the APG-65 Radar. The simulator, called SAPHIRE, provides a state-of-the-art synthetic environment for air-to-air combat. It can emulate the current fighter radar plus evoke significant enhancements developed in-house. DREO is currently upgrading SAPHIRE to demonstrate the effects of improving the radar memory and processor. The improved model will include a link to a CF-18 cockpit simulator at BAE Systems. DCIEM and DREO will use the crew-in-the-loop system to assess human factors issues and familiarize air requirements staff with the operation of an advanced air-to-air weapon system radar.

AIM-9 Missile Shelf Life Extension

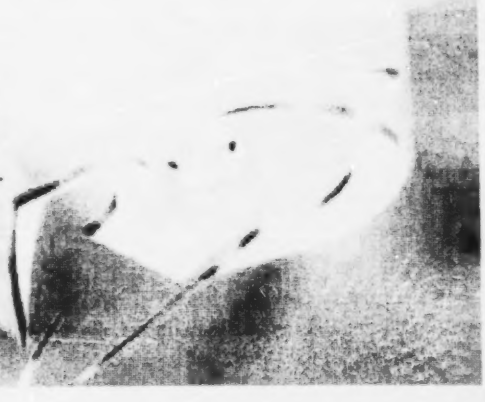
Following upon extensive analysis of the missile propellant, a DREV study has concluded that it is still safe to stockpile and use AIM-9 missiles even though their life had been deemed expired by the manufacturer. This will allow the CF to maintain readiness until a replacement short-range missile has been selected. The same analysis is now starting on the AIM-7 missile.

Rechargeable Lithium Battery

Under R&D contract funding, Electrofuel developed a prototype rechargeable military battery based upon the technology of lithium polymer electrolytes. These batteries are thinner, have better rigidity, and have higher energy density than those made with organic electrolytes. The low-temperature performance is outstanding, making this a significant step toward the fielding of a lithium-based rechargeable battery. Of importance to the military is that the technology provides flexible battery pack shapes.

Radar Warning Systems

Over the last two years, DREO has conducted a number of studies on behalf of the Directorate of Air Requirements to evaluate the suitability of a number of radar warning receivers considered for purchase under Project A2116 CF18 Radar Warning Receiver. These studies also include an option analysis comparing various approaches for extending the life of the existing ALR 67 radar and a range of potential replacement options. In the technology area, DREO



has completed a special receiver that measures intentional modulations on radar pulses in addition to the conventional ELINT parameters. This has been demonstrated to considerably reduce the number of ambiguous emitter identifications in radar warning receivers. This technology is being considered in the context of Project A2116 to provide a low cost upgrade of the ALR 67

CF-18 Life Preserver/Survival Vest (LP/SV) and Rigid Seat Survival Kit (RSSK)

Responding to a call from 1 CAD for immediate assistance, DCIEM designed and produced prototype improvements to CF-18 aviation life support equipment (ALSE) which were operationally essential for Canadian pilots in the 1999 Kosovo air campaign. All CF-18 pilots flying missions out of Aviano, Italy used the improved LP/SV and RSSK, which provided them with enhanced secure emergency communications, access to a personal weapon, and mission-specific survival equipment that addressed deficiencies in escape and evasion tactics. This work has led to a re-examination of CF-18 ALSE for wartime vs. peacetime use.

Self Defence against Advanced Laser Guided Weapons

DREV has further developed its innovative detection and countermeasure system against laser beam riders (LBR). Field trials involving a real LBR firing pod were successfully conducted. The signatures of one Canadian LBR were taken during a live firing exercise, and recommendations will be made to operators to ensure more covert engagements. A new laser warning system (LWS) based on HARLID, with an innovative local area network architecture, has been demonstrated, making it possible to add new detectors in a "plug and play" fashion. Advice was provided to the Project Management Office/Utility Tactical Transport Helicopter on the performance of the new LWS acquired to protect the CH-146 Griffon.

Command and Control Information Systems Program

Canadian Acoustic Surveillance Workstation (CASWS)

CASWS was successfully developed to provide a modern analysis and display system for "traditional" fixed surveillance arrays. Reserve capacity in the system could be used for additional processing and to interface to a command and control system. CASWS could also be used as part of the processing and display system for a rapidly deployable surveillance installation.

Interference Cancellation Algorithm

An effective communications interference cancellation algorithm has been developed that can be implemented in the HF surface wave coastal surveillance radars described in last year's Annual Report. This will permit the radars to work through heavy interference experienced at night.

Geospatial Data Warehouse

Geospatial Data Warehouse technology developed by DREV and its collaborators was featured during the Web Mapping Testbed project, sponsored by the Open Geographic Information Systems Consortium. As a result of this involvement, Geospatial Data Warehouse now incorporates break-through Extensible Markup Language (XML)-based geospatial technology that allows a user to connect to any compliant geospatial data warehouse and retrieve any available data, regardless of their spatial reference system.

Computed Electronic Countermeasures

A novel approach to generating false targets against high-resolution radars, entitled computed ECM (CECM), was conceived. CECM involves digital manipulation of a digitized radar pulse to allow independent and precise control of range, Doppler, and amplitude for hundreds of closely spaced targets (or complicated false targets with multiple scatterers). The basic algorithms have been developed and coded, and simulations have been successfully conducted to demonstrate the concept.

Entrust PKI

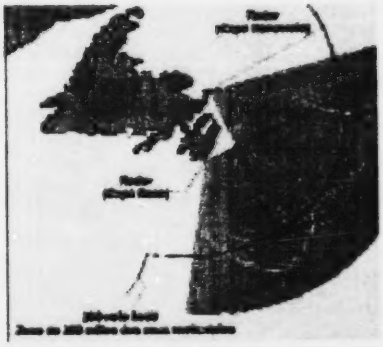
Formal Methods modelling was used successfully to validate the design of a new Internet standard security protocol, the Public Key Infrastructure (PKI) Exchange protocol, PKIX. The DREnet Entrust PKI, integrated with a full X.500 directory service database, is now supporting a wide variety of research groups, including international partners such as the complete TTCP community. It allows these groups to communicate in a trusted manner over the Internet.

Secure Management of Access Privileges

DREV has completed a research project in which "Electronic Visas" and "Fingerprint Recognition" are exploited to improve confidence levels in networked information systems, while simplifying the access procedure for the user. This project has earned a Federal Award of Excellence gold medal.

Rapid Response Communications Package (RRCP)

DREO and the Directorate of Telecommunications and Spectrum Engineering and Support developed the RRCP to demonstrate a satellite communications capability that filled a void between the large multi-channel military mobile



High Frequency Surface Wave Radar systems have excellent potential for coastal surveillance

Two major US manufacturers have announced new modem products based on CRC/DREO high-data-rate waveform designs.

terminals and the single channel INMARSAT terminals. The system is small enough to be transported as a single pallet, is capable of being assembled and operational in 60 minutes, and supports 6 to 12 simultaneous Integrated System Digital Network channels. Multi-channel voice and data operations were successfully demonstrated on both the Telesat and INTELSAT satellites. Subsequent to this testing, a second terminal was purchased for CFB Trenton and was used as the portable terminal during Operation Abacus. As part of the Air Communication and Control Squadron Modernization project, four more terminals are being procured.

JWID 99

The Joint Warfighter Interoperability Demonstration (JWID) 99, in which the Canadian Navy participated as part of a Multi-national Naval Task Group, successfully highlighted a number of advanced communications technologies. The Canadian Navy is initiating the Mobile Interoperable Secure Networks (MISN) project to deploy this technology on sea-based and shore platforms. The Navy has designated the MISN project (approximately $30M) as a critical capability.

High-Data-Rate HF Communications

Advances in high-data-rate HF communications at the Communications Research Centre (CRC) and DREO continue to gain world-wide exposure and influence commercial development. Prototype modems have been provided to industrial and defence organizations in the US, UK and France, and are being used to promote high-data-rate HF. With data rates of 10-16 KBPS, new services and applications are possible including: networked HF; image and video transfer; HF gateways for range extension of combat net radios in the battlefield; and sub-network relay. Two major US manufacturers have announced new modem products based on CRC/DREO high-data-rate waveform designs. In addition, the US Military Standardisation Group and NATO are developing interoperable standards, with a target for ratification in 2000.

DTED Generation

In support of J2 Geomatics, significant work has been completed on generation of Digital Terrain Elevation Data (DTED) using RADARSAT for polarimetric land-cover classification and shoreline mapping. The work on enhanced DTED generation, conducted in partnership with Atlantis Scientific, included direct support of CF and Allied operations in East Timor. The shoreline mapping was conducted jointly with the National Imagery and Mapping Agency in the USA.

Human Performance Program

Helicopter Deck-Landing Simulator

The validity of a relatively inexpensive helicopter deck-landing simulator was established. This device makes use of commercial off-the-shelf components as alternatives for the highly specialised, expensive components of a conventional simulator. The low cost technology demonstrator was developed by DCIEM, with reliance on DREA for providing ship motion histories and the University of Toronto Institute for Aerospace Studies for aerodynamic modelling. The simulator provides a stereoscopic view of the virtual environment, which includes a Canadian Patrol Frigate. In time, this device will be linked to an Officer-of-the-Watch simulator, a Landing Safety Officer (LSO) simulator and other simulators, including some in the US, to establish network performance criteria for simulation of the highly demanding helicopter deck-landing operations. This effort will demonstrate the feasibility of linking dissimilar simulators to provide team, collective, joint and coalition (interoperability) training involving various degrees of complexity.

A relatively inexpensive helicopter deck-landing simulator has been developed.

Physical Fatigue and Cold Exposure

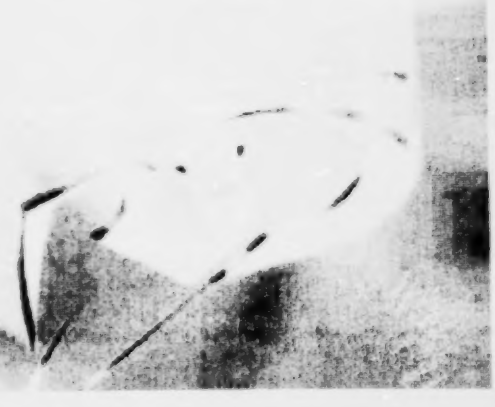
A collaborative study between DCIEM and the US Army Research Institute of Environmental Medicine was successfully completed to examine the potential effects of physical fatigue on thermoregulatory and immunological responses to cold exposure. The study was conducted to simulate challenging military operational scenarios in which prolonged and fatiguing physical work is followed by repeated cold exposures.

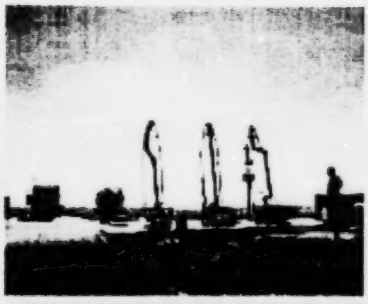
Forced Air Re-Warming System

For victims of hypothermia, chances of survival can be optimized if early re-warming can be initiated by the search and rescue crew. Effective field-portable technology has not been available. A DCIEM-designed prototype was completed of a forced air re-warming system for use inside helicopters and other emergency vehicles.

New Deep Diving Table

In collaboration with the US, Britain, Australia, and New Zealand, a new, deep (81 m) CUMA (Canadian Underwater Mine Countermeasures Apparatus) Repetitive Diving Table has been completed. This will enable divers to increase the number of dives safely completed in a fixed period of time and consequently increase the operational tempo of mine countermeasure efforts.





An international biological detection trial was conducted at DRES's Colin Watson Aerosol Layout – the world's first purpose-built bio-detection trials facility

Distributed Mission Training for the Air Force

A Project Arrangement with the US was signed. This agreement establishes the means for collaboration in the investigation and advancement of technologies enabling distributed mission training for the Air Force. A supporting Technology Demonstration project was approved that will develop an advanced interoperable simulator for the CF-18 in partnership with the US Air Force Research Laboratory. The goals of this project are to redress known deficiencies in visual simulation, to advance the development of constructive entities, and to reduce technical uncertainty about inter-simulator networking and the mix of simulator and in-flight training.

Bio-detection Trial Facility

DRES commissioned the world's first purpose-built bio-detection trial facility on its Experimental Proving Ground. The site is known as the Colin Watson Aerosol Layout (CWAL). An international biological detection demonstration trial was also conducted, involving scientists from the United Kingdom, Sweden, France and the Netherlands. The CWAL consists of a 10,000 square foot paved pad with four power test locations and four referee stations, to allow dissemination from all wind directions.

Medical Countermeasures

DRES completed a proof-of-concept study that demonstrates that immune modulators, which enhance a person's own immune system, can enhance survival to challenges with biological warfare agents such as plague and anthrax. Studies were also completed that identify the cyotoxicity mechanism of the chemical warfare agent mustard. These studies have discovered novel mechanisms of neuronal communication in the brain and have allowed DRES to challenge conventional theories of mustard toxicity.

CB Defence Training

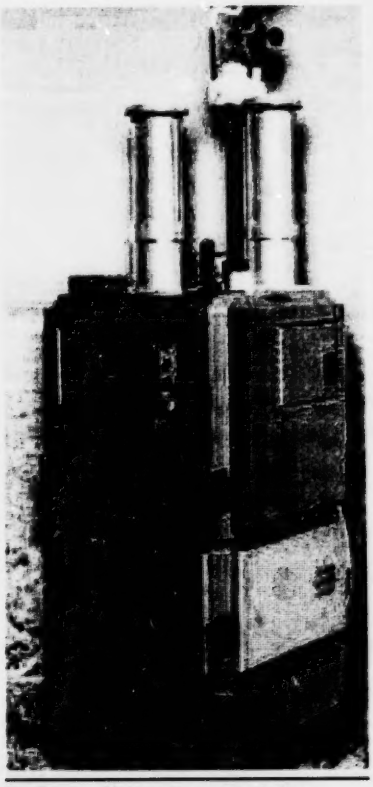
DRDC continues to provide support to the CF Nuclear Biological and Chemical School at CFB Borden. DRES provides live agent laboratory and field training. As well, DRES has conducted first responder workshops for chemical-biological terrorism.

Unscrambling Diver's Speech

Through co-operative work with CRC, the development of a diver's speech unscrambler has been completed. Normally garbled and difficult to understand, speech from a diver breathing a helium/oxygen mixture can now be clearly understood by surface support personnel. A license has been granted for the system to be manufactured commercially. Implementation in the Fleet Diving Units is expected to occur in 2000.

Canadian Integrated Biochemical Agent Detection System (CIBADS)

In 1999, significant achievements were made in the development of the field portable CIBADS. Phase 3 (CB Ident), which sought to develop near real-time identification of CB agents, is essentially complete, and Phase 4 (CB Detector), which integrates detection and identification, is well underway. A limited User Trial conducted at DRES in September 1999 evaluated the maturity of the most current CIBADS unit in terms of ease of use and operator maintenance requirements. Of even greater value was the feedback obtained from military end-users participating in the exercise. A team of British scientists also attended the trial as observers.



Significant achievements continue in the development of the CIBADS.

Corporate Highlights

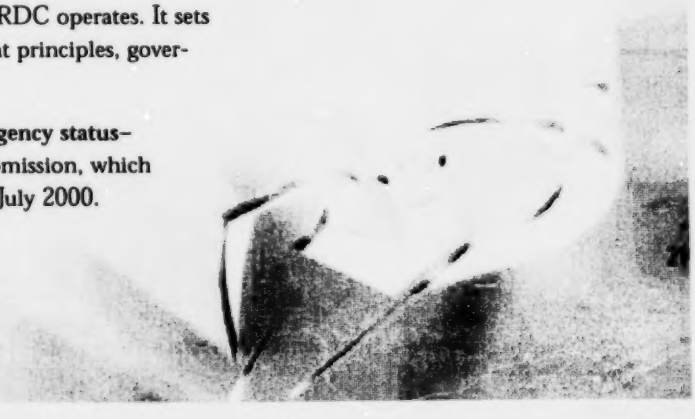
Alternative Service Delivery (ASD) Review and Agency Implementation

The ASD Review of DRDB was launched in September 1997. The main milestones in the process are noted below.

- The Screening Phase was completed in February 1998. R&D functions were deemed suitable for delivery by alternative means.
- The Analysis Phase was completed in June 1998. Various options were examined, and an agency within DND was selected for further study.
- The Development Phase was completed in July 1999. The decision was made to convert DRDB to an agency, with management authorities and practices that are within the purview of DND to grant, i.e. without introducing legislation.
- Agency Implementation got underway in mid July 1999. Stand-up of Defence R&D Canada as a Level 1 organization headed by ADM(S&T) took place on 1 April 2000.

The main tasks in Agency Implementation were:

- **Framework Document** – The charter under which DRDC operates. It sets out the Agency's mandate, business lines, management principles, governance structure and accountability framework.
- **Treasury Board Submission for Special Operating Agency status**– The Framework Document is the key part of this submission, which received the approval of Treasury Board Ministers in July 2000.



- **Business Plan** – A Level 1 plan was prepared and submitted in December 1999.
- **Human Resources Regime** – Arrangements were made to accept full departmental authorities for staffing and classification.
- **Infrastructure Arrangements** – Agreements were negotiated to transfer realty assets at DREA, DREV, DREO and DCIEM to DRDC. Transfer of realty assets at DRES will take longer to arrange, because of its high level of integration with CFB Suffield; the target date is 1 April 2001.
- **Administrative and Financial Arrangements and Processes**-- Moving to Level 1 status involved taking responsibility for many functions (along with the associated funding) formerly discharged for DRDB centrally within the Materiel Group.
- **Performance Measurement** – Concept development was completed, and the system was implemented.
- **Intellectual Property** – The division of responsibility between the Materiel Group and DRDC was negotiated. DRDC will manage and exploit IP arising from its activities. Resources were transferred from the Materiel Group to DRDC for this purpose.

3 Performance on Key Objectives

OVER THE PAST FEW YEARS, WE HAVE INSTITUTED THE PRACTICE OF SETTING KEY OBJECTIVES FOR THE ORGANIZATION TO ACCOMPLISH IN THE UPCOMING FISCAL YEAR AND BEYOND. THESE ARE PUBLISHED ANNUALLY IN OUR CORPORATE DOCUMENT CALLED "LOOKING FORWARD, STAYING AHEAD" (LFSA), WHICH TYPICALLY IS PRINTED IN THE FALL. THE 1998 ISSUE OF LFSA HAD FIVE KEY OBJECTIVES FOR ACHIEVEMENT BY THE END OF 1999/2000. OUR RECORD AGAINST THEM IS REPORTED BELOW AND WE ARE PLEASED TO OBSERVE THAT WE HAVE MET OR EXCEEDED ALL FIVE OF THESE OBJECTIVES.

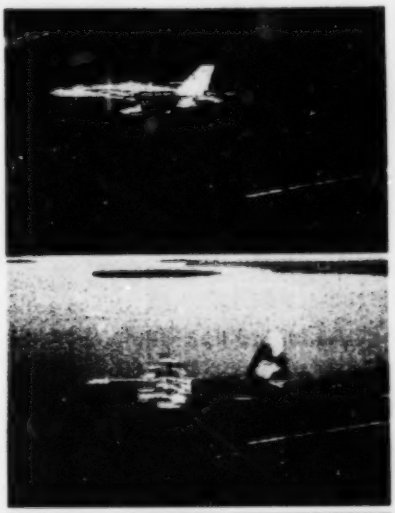
1. In partnership with the strategic planning element of the Department, to develop a Canadian position on the Revolution in Military Affairs.

DRDB moved quickly on this initiative and completed it in 1999, as described in last year's Annual Report.

2. To have at least 10 S&T initiatives/products developed by the Branch adopted for implementation by the CF.

Chapter 2 describes many such "products", ten of which are noted below.

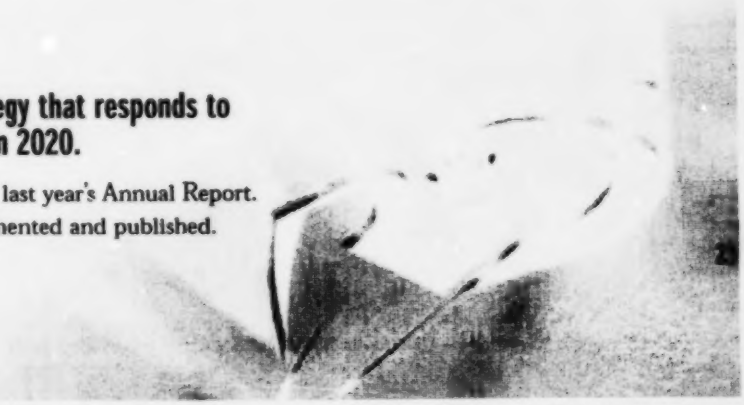
- Canadian Infrared Ship Signature and Ship Engagement Model
- Feasibility of integrating a fuel cell power plant into a submarine
- FIXOR – replacement for C4 in landmine neutralization
- Soldier Information Requirements
- Electronic thermal neutron activation
- Pyrophoric decoy flares
- Heads-up display for the Griffon helicopter night vision goggle
- AIM-9 missile shelf life extension
- Rapid Response Communications Package
- New deep diving table



Pyrophoric decoy flares have been developed to protect the CF-18 and CC-130 from IR seeking missiles

3. To develop a Technology Investment Strategy that responds to the needs of the Department and the CF in 2020.

Considerable progress on this objective was noted in last year's Annual Report. The Technology Investment Strategy has been documented and published.



4. To initiate at least five new Technology Demonstration Projects

The Branch has launched a Technology Demonstration Program (TDP) to demonstrate and validate technological solutions to CF operational requirements. The Program also gives our partners the opportunity to evaluate and display the utility of technology insertion. Table 6 shows the projects in the TDP as of the end of fiscal year 1999/2000. Six of these got underway in 1999.

5. To establish a business development strategy that maximizes the benefits of defence R&D. Targets for 1999/2000 are to leverage $26M from external partners and to generate $3M from external sources.

In 1999/2000, we exceeded each of these targets by roughly $1.7M. Chapter 6 provides some examples of collaborative arrangements with Canadian partners.

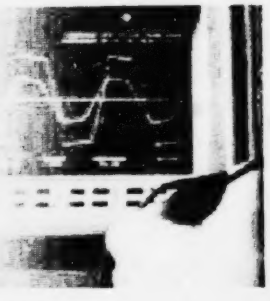
4

R&D for the Canadian Forces and National Defence

As noted earlier, the defence R&D Program for our five Client Groups is "packaged" into R&D Thrusts, and Service Level Agreements are negotiated annually with eachCG. These SLAs include several Major Initiatives per CG, as well as plans for the R&D Thrusts, with resources, schedules, milestones and deliverables described down to project level

Estimated resources by Client Group and Thrust are depicted at Table 5. Civilian Full Time Equivalents (FTEs) and total expenditures are shown. The latter figures were obtained by summing expenditures on civilian salaries, operations and maintenance, R&D contracts and capital equipment.

In Chapter 2, we presented highlights arising over the past year from the R&D programs that we conduct for the five CGs. We shall now supplement this anecdotal information with a review of progress on CG Major Initiatives and statistics on milestone delivery.



Major Initiatives

Maritime Program

New Way Ahead for Maritime C3I R&D

COMDAT project definition studies have been completed, and objectives, deliverables, and a demonstration plan have been finalized. The project charter and implementation plan have been drafted. Function Flow Diagrams of the CPF Command System are being produced as a bi-product of the Cognitive Task Analysis of the ORO position.

Way Ahead Study for Above Water Warfare

The Way Ahead Working Group has met regularly over the past year to define requirements for future work in above water warfare. System integration activities are seen to be critical, although it is still necessary to retain expertise in individual sensor areas. An outline for a Way Ahead document has been developed, and draft versions of each chapter have been written.

Shipboard Integration of Sensors and Weapon Systems (SISWS)

A pre-definition study for SISWS was conducted and used to prepare a proposal for a technology demonstration project, which was approved in principle. A scoping study will be carried out in 00/01 to assess the feasibility of the proposed approach and to establish resource requirements.

Co-ordination of AWW, C3I and UWW Activities

A working group has been established to ensure proper co-ordination between COMDAT, SISWS, and the proposed Sonar Information Management Technology Demonstration.

Low Frequency Directional Command-Activated Sonbuoy System (LoDICASS)

Prototype LoDICASS sonobuoys were developed by Hermes Electronics. Over-the-side trails on CFAV Quest were conducted in March. Preliminary evaluation of detection performance under the hostile acoustic conditions encountered during the trials indicates range improvements over conventional DICASS buoys.

Land Program

Technology Demonstration and Major Development Projects

Last year's CG2 Service Level Agreement proposed five Technology Demonstration Projects:

- High Capacity Tactical Communications Links (HCTCL)
- Intelligence, Surveillance, Target Acquisition and Reconnaissance (ISTAR)
- Future Armoured Vehicle System (FAVS)
- Hypervelocity Direct Fire Munition
- Blast Protection from Emerging Threats

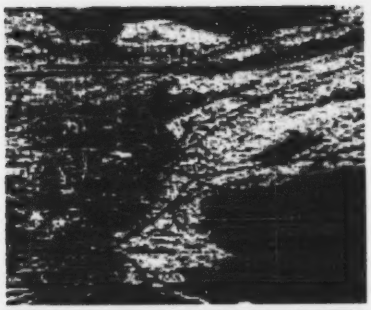
A Major Development Project, Stand-off Demolition Charge, was also proposed. The R&D Executive Committee approved the HCTCL and FAVS Projects to start in FY00/01, whereas the ISTAR and Hypervelocity Munition Projects will start in FY01/02. The projects on Blast Protection and Stand-off Demolition Charge will be pursued as technology applications projects in the Military Engineering Thrust.

The HCTCL and ISTAR projects respond specifically to DND's strategic direction to "focus defence R&D efforts to target leading-edge technologies, while capitalizing on Canadian technological know-how to build and extend CF distinctive competencies (particularly in the areas of space, telecommunications, information and sensing)". The FAVS and Hypervelocity Munition Projects address the CLS's change objective "to convert the land forces to a primarily wheeled fleet of combat and support vehicles". Also, these two projects will help to answer the question: "Will technology allow us to fit 70 tons of lethality and survivability into a 20 ton package?"

Promotion of S&T Awareness within the Army

A number of actions were undertaken, including:

- convening a meeting of the Army Research Working Group at DREV,
- enrolling a member of the DRDC staff in the Land Forces Technical Staff Program,
- participating in the symposium on the Future Security Environment organized by the Directorate of Land Strategic Concepts,
- participating in the symposium on the Tactical Battlefield of the Future organized by the Combat Training Centre.



Synthetic Aperture Radar image of CFB Petawawa

Air Program

Technology Demonstration and Major Development Projects

Two Technology Demonstration Projects were proposed last year: Tactical Aviation Mission Systems Simulator (TAMSS)and Maritime Air Littoral Operations (MALO). TAMSS was approved, but MALO was not.

Last year's SLA served notice that the contract for SpotSAR Advanced Development would be terminated and the project redefined. These actions were taken. The remaining resources in the project are directed toward advancing SpotSAR technology and preparing for inclusion of this technology in the radar upgrade of the CP-140 Aurora.

The Aircrew Cockpit Demonstrator enables virtual prototyping of cockpit instrumentation for human factors assessments

Airborne Surveillance Concepts

DRDC responded to an invitation to participate in the Global Hawk Unmanned Aerial Vehicle Project by contributing an appropriate target mix for a high altitude aerial reconnaissance exercise over Canada and by establishing and securing approvals for such an overflight. The preparatory work included demonstrations of live imagery fed directly into a CF command centre. This has stimulated serious consideration of a more pronounced role for airborne ISR by the CF. As a direct result, the Land Forces have identified a requirement for improved data links in the CP-140 modernisation.

Pyrophoric Decoy Flares

The advanced development project was completed, as noted under Air Program Highlights in Chapter 2.

Directional Infrared Countermeasures

A TIF project got underway to employ a laser system to defeat IR missile seekers by dazzling.

Hard Chromium Alternative Technologies

A CA/US multidisciplinary partnership has been formed to solve the key technical challenges surrounding the replacement of chromium coatings on aircraft. The aim is to replace hard chromium electrodeposits in response to new legislation covering health and safety exposures and environmental toxicity of hexavalent chromium. In the last year, work has progressed well towards characterizing an alternative coating that is applied using a high velocity, high temperature jet spray.

Simulation Strategy for the Air Force

Good progress has been made on this initiative. Several examples of simulation applications have been given under Air Program Highlights in Chapter 2.

Command and Control Information Systems Program

Initiate an R&D Program in Information Operations

April 1999 saw the stand-up of the new Information Operations Section at DREO. By March 2000 the strength of the Section reached 12, of whom 11 are Defence Scientists. The program includes: methods of processing the large quantities of data produced by commercial intrusion detection systems, experimenting with public-key infrastructure and directory systems, and development of data mining techniques.

Recognized Maritime Picture (RMP) and Common Operating Picture (COP)

Progress has been made in correlating inputs to the RMP from multiple near real-time sources. A set of trials in March 2000 collected a ground-truthed data set from several sources, which can be used to help define the methods of level 1 fusion appropriate to the formation of the RMP. The decision by the CF to pursue a National Level COP based on the GCCS COP structure, and to produce the COP by combining the RMP, the NORAD picture and other information, is a key factor in determining which options to study.

Capturing R&D Requirements of the Joint Client

The greatest challenge is to address requirements in joint surveillance. The process of identifying these requirements has evolved very well, with initiatives from both the Vice-Chief of Defence Staff and the Deputy Chief of Defence Staff facilitating the formation of an ISR working group. This group, aimed at defining the ISR requirements of the CF at the strategic, operational and joint tactical levels, will become the primary source of guidance for the Agency to capture ISR R&D needs.

Implementation Plan for the Agency's C2 Program

This initiative involved examination of C2 activities in all five of DRDC's Client Groups to formulate an approach to bring together adequate resources to support a first-class R&D program. All DRDC's activities directly and peripherally linked to C2 were identified, assessed and mapped across the taxonomy of an ideal C2 R&D program. Recommendations are being prepared on how to restructure the C2 R&D program to maximize synergy, comply with the Canadian Forces Command System and satisfy the requirements of the Environmental Chiefs of Staff.

Space-Based Radar GMTI Surveillance.

Demonstration of a ground moving target indication (GMTI) capability on Canada's RADARSAT-2 satellite received MND approval in February 1999. The ground station processor and simulation work has progressed over the past year. Equipment required for the signal processing has been acquired, and the signal processing simulation work should be finished by the summer of 2000. Co-operative activities with the UK and US are proving to be extremely beneficial to all concerned. An additional collaborative opportunity has been identified with the NATO Command, Control and Consultation Agency, under a technology demonstration project that will fuse inputs from different GMTI sources to provide an improved operational picture to the war fighter.

Demonstration of a GMTI capability on Canada's RADARSAT-2 satellite received MND approval in February 1999.

Human Performance Program

Modelling and Simulation

- DRDC's Way Ahead on SMART (Simulation and Modelling for Acquisition, Rehearsal and Training) was defined.
- A CA/US Project Arrangement (PA) on Distributed Mission Training was signed. The Charter and Implementation Plan for a Technology Demonstration Project supporting the PA were drafted.
- The validity of a low-cost helicopter deck landing simulator was established (see the Human Performance section of chapter 2).

Military Operational Medicine

- A critical review of this Thrust was completed, and its projects were realigned with operational requirements. In particular, resources for the Operational Health Hazards Project were increased.
- The development of a prototype of a field-deployable blood pressure and heart rate monitor that is resistant to environmental noise and vibrations was completed; it awaits further validation by field trials in rescue helicopters and land ambulances.

A new deep diving table has been developed for use with the Canadian Underwater Mine Countermeasures Apparatus

- A hemorrhagic shock model was successfully developed to assess the efficacy of conventional and proprietary resuscitative fluids. The superior efficacy of a supplemented hypertonic fluid was demonstrated.
- A comprehensive environmental atmospheric study on board an Oberon class submarine was completed. The report recommends an air monitoring system upgrade and air-quality improvement measures.
- A DCIEM/US Army study of the impact of operational fatigue and cold exposure on the immunological and thermoregulatory responses was completed, as noted in Human Performance section of chapter 2.
- In response to the concern of potential morbidity and mortality caused by exertional heat illness (EHI) in CF recruit training, a preliminary study was completed, reporting the rate of EHI incidence and procedural and logistic approaches to prevent, where possible, heat exposure-related medical incidence.

Diving

- A new deep diving table was completed, as noted in Human Performance section of chapter 2. A study was undertaken to examine the current state of emergency hyperbaric technology for submarine escape and survival.

Human Factors in Military Systems

- A Way Ahead Working Group on Human Factors R&D was formed. It completed its report in summer 1999.
- A study was undertaken to determine the scale of effort to support the application of Human Systems Integration (HSI) to a major acquisition project. A proposal was made for an HSI Technology Demonstration Project, but it did not receive approval. An alternate plan has been developed.
- The ongoing initiative to provide the most current and effective human factors tools and techniques led to an agreement with the US and UK to collaborate on the development of the Improved Performance Modelling Environment.
- To re-establish a technology base in Human-Computer Interaction, two DSs were re-assigned and two DSs were recruited to form a group within DCIEM's Human Factors of Command Systems Section.

Protection Against Biological, Chemical and Radiological Hazards

- Work was completed to recommend materials and final garment configuration for the Lightweight Chemical Protective Suit for Hot Environments. This will be migrated to the acquisition project, Hot Weather Chemical Warfare Garment.

M121

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- A new NBC protective glove has been transferred to industry. The new glove design is based on extensive studies on fit, durability, performance and materials.
- The final commercial formulation has been generated for the Canadian Aqueous System for Chemical-Biological Agent Decontamination (CASCAD) product. It is effective against CB agents and will remove nuclear particles.
- Work on liposome-encapsulated ciprofloxacin has progressed to the stage where it is ready for technology demonstration of an inhalation device delivering the antibiotic.
- A unique effort to develop anaesthetic protocols for casualties poisoned with nerve or blister agents has been successfully undertaken.

Statistics show a 76% achievement rate for DRDB on a total of 377 milestones for 1999/00.

Milestone Delivery

Thrust Co-ordinators and Thrust Leaders have reviewed each Thrust and noted the success rate at meeting milestones during 1999/00. Milestone delivery statistics are tabulated below, aggregated by CG. For four of our CGs, milestone data are provided for both full completion (100%) and partial completion (90%, 80%, etc.). For the Land Program, however, we have data for full completion only. Note that these statistics do not include milestones that were re-scheduled by mutual agreement with the client.

		Maritime Program	Land Program	Air Program	CCIS Program	HP Program
Total Milestones in 1999/00		75	112	63	71	56
Milestones Achieved	100%	50	60	46	51	38
	90%	3		0	2	2
	80%	3		2	2	3
	70%	4		4	6	2
	60%	1		0	2	4
	50%	4		8	2	6
	<50%	10		3	6	1
Overall Milestone Achievement		83%	54%	87%	86%	88%

Using the above data, we compute a 76% achievement rate for DRDB on a total of 377 milestones. Compared to the milestone performance reported in the 1998/99 Annual Report, we see two important changes:

- A new NBC protective glove has been transferred to industry. The new glove design is based on extensive studies on fit, durability, performance and materials.
- The final commercial formulation has been generated for the Canadian Aqueous System for Chemical-Biological Agent Decontamination (CASCAD) product. It is effective against CB agents and will remove nuclear particles.
- Work on liposome-encapsulated ciprofloxacin has progressed to the stage where it is ready for technology demonstration of an inhalation device delivering the antibiotic.
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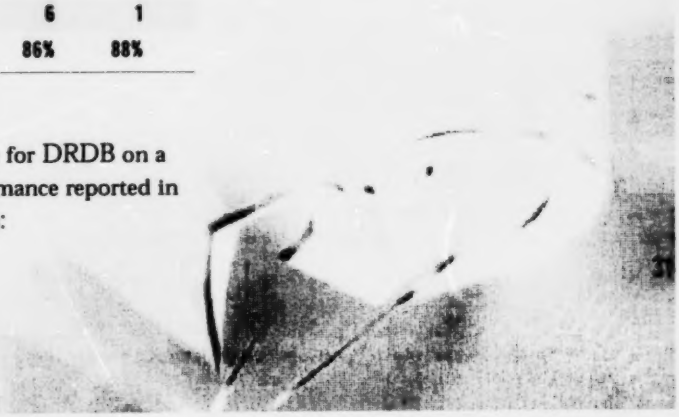

Milestone delivery statistics indicate that the Agency's overall performance in 1999/00 is much better.

- Our overall performance in 1999/00 is much better.
- The total number of milestones is much lower for four CGs, and the numbers are more consistent across the CGs. This indicates a better understanding of what should constitute a milestone and greater consistency in the relationship between resource expenditure within a CG and the total number of milestones in a year.

Client Satisfaction

In last year's Annual Report, we presented results from a Client Satisfaction Survey which involved the application of a questionnaire, with accompanying interviews, to selected managers in all five of our Client Groups. We contracted-out the conduct of the survey, so as to assure an arm's length, unbiased interpretation of data and information. The consultants' report received wide distribution within the Branch's CF/DND client community.

The results of this examination were generally positive. However, there were some areas of concern, and they have been addressed over the past year. For example:

- We examined the issue of timely services to the CCIS Client Group and clarified the role of R&D in the context of command and control in DND.
- We have responded to the recommendation to provide Client Groups with a better understanding of the Branch's capabilities. We have informed clients about our different types of R&D activities (e.g. technology investigation, technology application, technology investment fund, and technology demonstration) along with the proportions of resources devoted to each.
- Some clients suggested that we consider additional internal "marketing" of our capabilities within DND. This is part of our new communications strategy.
- We have addressed the issues of making the R&D Program Review Committee more relevant and effective as a decision-making body and of making the Service Level Agreements with our five Client Groups more "user friendly".
- Measures were taken in response to some dissatisfaction regarding the operational medicine program.

We have decided to conduct a Client Satisfaction Survey of this nature every two years. The next survey will take place early in fiscal year 2001/02.

5

S&T Policy and Advice

As noted in Chapter 1, there are three Thrusts in Business Line 2. Their names and objectives are listed in Table 4, and estimated resources are given in Table 5. Highlights and achievements included the following

- Initiated a Technology Outlook Thrust to provide a structured approach to looking out for emerging technologies and assessing their potential relevance to Canadian defence, by exploiting national and international networks, focussing internal expertise and engaging outside experts. Projects in this Thrust include:
  - symposia/workshops on emerging issues
  - rapid expert assessment of emerging technologies
  - technology watch (national and international)
  - knowledge management
- Co-sponsored a Departmental symposium entitled "Creating the Canadian Forces of 2020" that focused on Concept Development and Experimentation (CDE) and Modelling and Simulation (M&S). This symposium was instrumental for the development of a DND policy on M&S/CDE in Departmental and CF planning.
- Published a Concept Paper related to the Revolution in Military Affairs (RMA), "Canadian Defence Beyond 2010: The Way Ahead".
- Provided an S&T perspective to the DND/CF Strategic Capabilities Plan (SCP) Working Group and Departmental force planning scenarios. The SCP Working Group is responsible for force development and the generation of concepts and options for determining national capabilities. It provides a venue for advancing RMA-related activities.
- Provided DND with expert advice on such initiatives as: C4ISR study, asymmetric threat assessment, strategic lift study, and NATO's Defence Capabilities Initiative.
- Published several S&T Issue Papers, including: Countering CB Terrorism; Modelling and Simulation – Enabling Better Decisions; and Unmanned Aerial Vehicles – Force Multipliers.
- Completed and published a Technology Investment Strategy that addresses CF requirements for 2020 and identifies the most promising R&D activities for delivering future technology needs.
- Managed the Technology Investment Fund (TIF) process to provide investment in innovative research to stimulate activity in high risk/high pay-off areas consistent with the overall Technology Investment Strategy. The TIF's funding level was $4M in FY 1999/2000 and $6M in subsequent years. Seven new TIF projects started in 1999/00 (see Table 7), and nine projects were approved for start-up in 2000/01.

6

S&T with National Security Partners

WE RELY ON OUR PARTNERS, BOTH NATIONAL AND INTERNATIONAL, TO PROVIDE US WITH ACCESS TO A BROAD TECHNOLOGY BASE AND TO PARTICIPATE IN DELIVERING THE DEFENCE R&D PROGRAM. AT THE SAME TIME, WE CONTRIBUTE TO NATIONAL WEALTH GENERATION BY TRANSFERRING TECHNOLOGY AND KNOWLEDGE OUT OF OUR LABORATORIES FOR USE IN CANADIAN INDUSTRY. ENHANCING THE EFFECTIVENESS OF THESE PARTNERSHIPS IS A KEY ELEMENT OF OUR R&D STRATEGY, AND TO THIS END WE ARE TAKING NEW INITIATIVES TO PROMOTE COLLABORATION AND EXPAND EXISTING ARRANGEMENTS

Increasingly, we seek to engage national partners in cost-shared collaborative projects. An outstanding example of such an arrangement is the RADARSAT-2 program. As noted in Chapter 4, DND is funding the addition of a ground moving target indication (GMTI) mode for this satellite. This will demonstrate the first space-based GMTI capability in the world. DND negotiated an arrangement with the Canadian Space Agency that will add the GMTI mode to the $400M program for a cost to DND of $14.5M.

The Defence Industrial Research (DIR) Program, a 50/50 cost shared arrangement with industry, continues to provide an important and successful mechanism for leveraging. Through the DIR Program, we solicit innovative R&D proposals from industry that have potential defence application. In 1999/00, there were 39 active DIR projects, on which expenditure totalled $6.34M during the fiscal year. The projects are listed in Table 8. Some recent DIR highlights are noted below.

Magneto Inductive Systems

This company has developed a technology with the potential for arming and disarming naval minefields, with both short range (beach clearance) and long range applications. The Canadian Army also has an interest in this technology for land minefield control and demolition tasks, and as a perimeter security detection/sensor system. The UK is also interested in it for communication applications between aircraft and submerged submarines.

Tactical Technologies

In collaboration with DREO, this company is developing an integrated anti-ship missile defence simulation, including chaff, active decoys, on-board ESM and jamming systems, pulse doppler fire radar, semi-active missile system and radar-directed close-in weapons. This technology is relevant to the Navy Command and Control and Air Defence Replacement System, to be installed on all Advanced Logistics Support vessels, as well as the SISWS Technology Demonstration Project.

I.T.S. Electronics

Current and previous DIR projects have resulted in low-noise amplifier products for such applications as the Iridium communications satellite program, the Rockwell Collins Exo-Atmosphere Kill Missile, the US THAAD area defence system, the C41 Intelligent Battlefield HUMV, and the European Tornado aircraft.

A.U.G. Signal

The company has established competitive technology in the areas of signal image and data processing for detecting and recognising military targets. The company has worked with DREO and DREV to produce combined electro-optical and SAR space-based algorithms for surveillance applications, and is developing detection and recognition products from space-based radar algorithms.

Cogigraph Technologies

This project involves a cognitive, learning-centred (rather than behaviourist) approach to a computerised Instructional Design Tool, based on software modelling of the "content of learning". This project has involved direct input by CF clients. The intention is to integrate this technology into DND's Individual Training and Management Information System, with twenty site licences as deliverables to DND.

SENSOR Technology

This company has become the largest manufacturer of piezoelectric products in Canada, based principally upon DIR support and collaboration with DREA, including licensed technology transfers. Previous DIR projects resulted in world-wide sales of hydrophones for towed arrays. A current DIR Project based upon licensed Barrel Stave Projector technology from DREA is at an advanced stage, with the prospect of large commercial prospects in the near future.

Table 9 lists patents, reports of invention and licensing agreements. These examples illustrate a healthy level of technology transfer from DRDC to Canadian industry.

We made substantial progress on our initiative to generate revenue through exploiting our S&T base to serve the needs of clients outside DND, including Canadian industry and other government departments. Such work and the associated income will help DRDC to develop and maintain its technological capabilities. In 1999/00, revenue was $4.7M, in comparison to the target of $3M. Table 10 provides some examples of revenue-generating projects.

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The DND/NSERC Research Partnership Program, described briefly in Annex A, provides a vehicle for DRDC-industry-university collaboration. The following projects have received approval.

Title	Firm	University	DRE	Total Project Cost	DND Share
Nonlinear signal processing for sensor surveillance	**AUG Signals**	**Calgary**	**DREO**	**$247,000 (over 3 yrs)**	**$90,000**
Outdoor mobile robot for surveying and military field support applications	**Geco-Prakla**	**Alberta**	**DRES**	**$176,000 (over 2 yrs)**	**$40,000**
Diagnostics and therapeutics of alpha-viruses employing recombinant antibodies	**Cytobiotechnics**	**Alberta**	**DRES**	**$300,000 (over 2 yrs)**	**$150,000**

Electro-Optics Engineering & Evaluation Centre (EEEC)

Under Business Line 3, we may undertake projects for DND that fall outside the R&D Program. For example, DREV has created the EEEC to address CF requirements for engineering, testing and evaluation of EO materials, components and systems. In 1999/00, 29 tasks were performed for a business volume of $750K. This represents a doubling in revenue compared to 1998/99. Prominent activities included:

- Technical specifications for the RFP for the NODLR mid-life upgrade.
- Assessment of laser protection in three types of binoculars.
- Mechanical and optical compatibility of the US universal tube for the PVS-504.
- Field trial to assess effectiveness of sniper camouflage.
- Development of a unique sensor sensitivity measuring device for the AAR-47 Missile Approach Warning System up to production level.

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7

Corporate Affairs

Human Resources

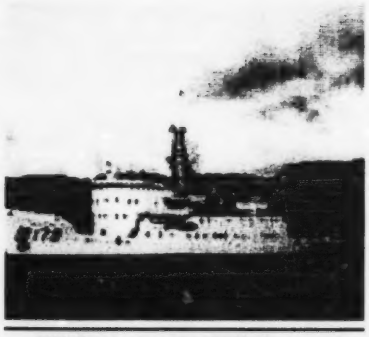
HR initiatives during 1999/00 were largely concerned with preparations for Agency implementation, such as getting ready to exercise full DND authorities for staffing and classification. A transfer of resources from the HR-Civilian Group was negotiated to cover these two functions, as well as compensation services. The Agency's managers are being trained to exercise staffing authorities with support from HR specialists. As to classification, HR specialists will perform this function under the current classification system, but once the Universal Classification Standard (UCS) is implemented, managers will be trained to classify positions.

At the beginning of the Agency Implementation Phase, the intent was to seek additional HR authorities via Separate Employer status. However, after discussions with staff in the Treasury Board Secretariat and consultation at senior levels in DND, it was decided not to pursue Separate Employer status at this time and to implement DRDC's HR objectives within the existing framework insofar as possible. In the near term, priority is on:

- Extending the person-oriented approach and career management (currently in place for Defence Scientists) to all employees.
- New approaches to performance evaluation, rewards and recognition.

Another HR initiative related to Agency Implementation was the Cultural Change Working Group, which consisted of 12 employees with balanced representation from all our sites and occupational communities. Its mandate was to define target values and key cultural characteristics for the Agency, to assess the extent to which our current values and culture align with these targets and to identify management practices to reinforce the target values and culture. The Group recommended a five-track approach to implementing cultural change: (1) Mission, Vision and Values; (2) Leadership Development; (3) Structure, Accountability and Decision-Making; (4) Performance Management; and (5) Business Practices and Development. DRDB management accepted the Group's recommendations, and implementation is in progress.

Another significant initiative was Odyssey 2000 at DREV. It involved all DREV employees to some degree, with a core team of about 30. Its mandate was to examine a wide range of processes and practices, in order to position DREV as a world-class R&D centre. It resulted in 108 recommendations, on which implementation is well underway.



CFAV Quest returned to DREA after an extensive mid-life refit and modernization

Administration and Infrastructure

As with HR, most initiatives in administration and infrastructure in 1999/00 were concerned with preparations to become a Level 1 organization with several additional special authorities. These initiatives have been noted under Corporate Highlights in Chapter 2. Other noteworthy activities and accomplishments are noted below.

- Response to the demands imposed by the Universal Classification Standard (UCS) project included:
  - creating five Functional Teams to prepare model work descriptions;
  - drafting work descriptions for positions not covered by models;
  - extensive consultation and broad collaboration with various stakeholders;
  - participating in evaluation committees;
  - participating in the Departmental UCS Core Team and various interdepartmental committees.
- Extensive testing of computer systems took place to determine if they were year 2000 (Y2K) compliant. The new year arrived with no Y2K problems in DRDB.
- DREA's research ship, CFAV Quest, returned to Halifax in October 1999, after more than two years in an extensive mid-life refit and modernisation. Special attention was given to maintaining her acoustic integrity and habitability. The refit extends Quest's operating life to 2015.
- A significant upgrade to DREA's Dockyard Laboratory seawater facility was concluded in 1999. This facility is used to test the effects of salt water on material and devices used in maritime applications.
- DRES commissioned an advanced bio-aerosol test chamber for R&D on biological agent detection and identification. It has a special capability to evaluate stand-off detectors and a system for real time measurement of aerosol concentrations – the first such facility in the world.
- DCIEM commissioned the construction of a new acceleration capsule and design of a new centrifuge arm which will give it the capability to conduct forefront acceleration research on transitions from +G to –G. This will address critical life support systems and training problems in "push-pull" aerospace environments.

- A new Ammunition Workshop was constructed at DRES.
- The Collaborative Planning and Management Environment was designed in-house to assist managers in program planning and monitoring. Though development started only in January 2000, the system was sufficiently advanced by spring 2000 for use in preparing Service Level Agreements.
- Work progressed on the Activity Based Costing (ABC) initiative. Data were collected and analysed. Workshops were conducted at the DREs and HQ, in which results were examined and discussed. A working group of senior managers was created to seek efficiencies along both vertical and horizontal lines.
- The Defence Scientific Information Service implemented the CANDID-on-the-Web service, accessible on both the Internet and the DND Intranet, to provide clients with the capability to locate defence scientific and technical reports. Some reports may even be downloaded directly.
- DRDC is now connected to CA*Net 3, a state-of-the-art high-speed Internet network designed especially for scientific organizations and educational institutions. Among other advantages, this connection will increase DRDC's capability for real time distributed simulation with national and international collaborators.

International Collaboration

DRDC COLLABORATES WITH OTHER NATIONS IN A DIVERSE MIXTURE OF MULTI-LATERAL AND BILATERAL ARRANGEMENTS TO PROVIDE THECF AND DND WITH GLOBAL ACCESS TO ADVANCED DEFENCE TECHNOLOGYINFORMATION AND EXPERTISE, AND TO FACILITATE INTEROPERABILITY WITH OUR ALLIES

Two multi-lateral bodies are especially important: The Technical Cooperation Program (TTCP) with the US, UK, Australia and New Zealand; and the NATO Research and Technology Organization (RTO). Table 11 shows the structure of these bodies and indicates which R&D Thrusts benefit from the technical activities. Table 11 also provides examples of collaboration for our most prominent bilateral arrangements.

Another illustration of the importance of our international linkages is that many of the major achievements given in Chapter 2 involved international collaboration to a significant degree. Examples include: SHIPIR/NCTS, Airborne Sonar Systems, Dorado, Dynamic Stability Criteria, Wheeled Vehicle Landmine Protection, Foot Protection System, Electronic Battle Box, Defensive Aids Suite, CACTUS, Air-to-air Missiles, Flight Dynamics, JWID 99, High-Data-Rate HF Communications, DTED Generation, Physical Fatigue and Cold Exposure, New Deep Diving Table, Distributed Mission Training, Bio-Detection Trial and CB Defence Training. Some additional examples follow.

- A highly successful Canadian-Norwegian-Swedish trial to test the performance of a variety of buoy-mounted electromagnetic sensors.
- Collaboration through TTCP to achieve a better understanding of the role hydrogen plays in weld failures.
- A NATO study examining the relative performance of vertical and horizontal source arrays in LFA sonars.
- Collaboration with the Netherlands (TNO Physics and Electronics Laboratory) on the analysis of self-noise in acoustic dipole sensors and towed array shape estimation.
- A joint project with Australia on decision aids for undersea warfare.
- Final Operational Evaluation of the NATO Data Fusion Demonstrator project, which took place in Italy in September 1999.
- TTCP Key Technical Activity on environmental aspects of energetic materials.
- Collaboration with the Netherlands (TNO Prins Maurits Laboratory) on rocket ramjet propulsion.

- A collaborative trial with the French Army in the DCIEM climatic suites to evaluate the efficacy and side effects of using a new French "alerting" drug under conditions of sleep deprivation, hard exercise, and heat stress.
- The US/UK/CA MOU on CBR defence, under which activities include: medical countermeasures, concept of medical defensive operations, detection of hazardous materials, realistic CB scenarios for operations other than war, digitization of CBR warning and reporting, antibody development, and site remediation.
- NATO Modelling and Simulation Group, which enables us to take advantage of existing and new opportunities in M&S. The network also provides a useful window on technology trends and opportunities world-wide.

We are seeking to expand collaboration with the US. Our Technology Demonstration Program should provide especially good opportunities for collaboration. For example:

- The ISTAR Project will demonstrate interoperability and enhanced technological concepts in concert with the US Army Experimentation Centre, leading to participation at the NATO Joint Warfighter Interoperability Demonstration 2003.
- The Hypervelocity Direct Fire Munition Project will involve collaboration with the US Army to demonstrate the concept of a missile that would provide the firepower of a 70 ton main battle tank in a light combat vehicle.
- The Advanced Distributed Mission Training Project will involve collaboration with the US Air Force Research Laboratory.
- There is a high level of US interest in the Space-Based Radar GMTI Project.

The 1999 issue of LFSA includes a Key Objective of leveraging $40M from international allies by 2004. We are developing a process to capture such leveraging data in a more rigorous manner. Current indications are that we will exceed this target by a comfortable margin.

Excellence in Science

AN S&T ORGANIZATION MUST MAINTAIN A HIGH STANDARD OF SCIENTIFIC QUALITY IN ORDER TO DELIVER R&D PRODUCTS AND ADVICE THAT ARE VALUABLE AND CREDIBLE. TO ASSESS OUR STANDING IN THE SCIENTIFIC COMMUNITY WE TRACK A NUMBER OF INDICATORS OF EXCELLENCE IN SCIENCE AND CONDUCT PEER REVIEWS OF DEFENCE TECHNOLOGY AREAS

Scientific Indicators

- Our staff published 255 papers in the scientific literature.
- Our staff made 323 scientific presentations at national and international conferences.
- Our DREs published 220 technical documents. In addition, 161 technical reports resulted from research contracts funded by the DREs.
- Technology transfer to Canadian industry took place across a broad spectrum of our R&D activities. Table 9 lists 33 patents and reports of invention, 20 recently completed licensing agreements and 23 pending licensing agreements.
- 21 of our staff received national and international awards and honours. See Table 12.
- DRDB participated in 94 national S&T activities (councils, networks, projects and other collaborative arrangements).
- DRDB was active in 326 international defence S&T activities (formal programs, projects, working groups and information exchange arrangements).

Peer Reviews

During the past year we conducted peer reviews of Radar and Navigation Technology at DREO and Command and Control Technology at DREV. Both peer reviews were greatly enhanced by a technique that we introduced in 1999, which involves the administration of a questionnaire covering all pertinent aspects of a technology program. The technical team under review completes the questionnaire first (self-assessment). After the technical team's presentations have been completed, the peer review team completes the questionnaire and, in a debriefing of senior establishment management, compares its responses with those of the technical team.

We have found that this procedure provides three significant advantages. First, the process of self-assessment is extremely useful for the technical team members, providing them the opportunity to give their own program a critical

evaluation in a structured manner. Second, the process ensures that the review addresses all questions of concern to management. Third, the peer review team's completed questionnaire, by itself, provides the "meat" of its report in a format which is immediately useful to both the technical team and DRDC management.

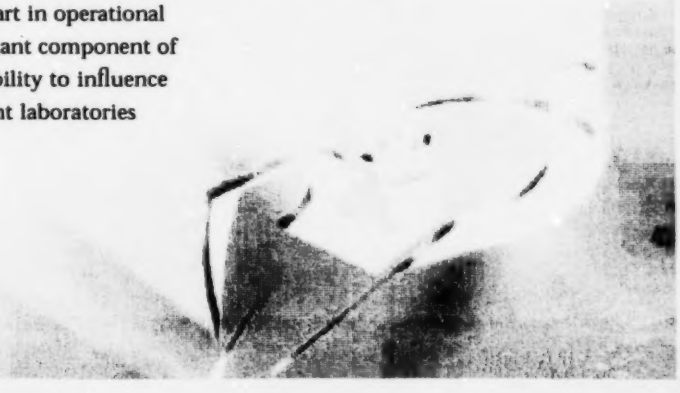
The review team for Radar and Navigation Technology noted a number of strengths in DREO's Airborne and Space-Based Radar teams, including: technical strategy and plans, use of external resources, value to clients, quality of technical output, technology transfer, and facilities. Special note was made of DREO's capabilities in synthetic aperture radar and exploitation of RADARSAT. The Navigation team also received favourable ratings. Problems were noted with the Surface Radar program, but still the high-frequency surface wave radar project received praise for its technical achievement and surveillance potential.

The review team recommended that capabilities be strengthened in: time-frequency analysis, space-time adaptive processing, pattern classification, adaptive and learning systems, neural networks, non-linear filtering, and multi-sensor fusion.

The review team for C2 Technology at DREV was very impressed with the calibre of the research, rating it as "generally very good to excellent, with some of the work achieving world class level". The reviewers also made special note of: outstanding leadership; highly dynamic personnel and excellent morale; and ambitious scope of the research program, with effective leveraging and collaboration. The technical team received high ratings for: technical strategy and plans, team skills and competencies, value to clients, quality of technical output, and technology watching. The reviewers were particularly impressed with the following projects: Electronic Battle Box, Land Intelligence and Electronic Warfare Automation, Open Geospatial Datastore Interface, and Cognitive Work Analysis.

The review team noted the highly strategic nature of the program and recommended "still closer connections with operations within the Forces". Another key observation was: "Full success in this area ... requires an awareness which extends beyond C2, reaching to the overall structure and mindset of the Forces. Gaining further operational experience and taking part in operational experimentation jointly conducted with the CF is an important component of that process as it provides leverage into the long term capability to influence doctrine. This is an area where collaboration with equivalent laboratories related to allied forces is highly beneficial."

The Dual Inertial Integrated Navigation System is a key product of Navigation R&D at DREO



10 Conclusion

AS THE FOREGOING CHAPTERS DEMONSTRATE, WE HAVE MOVED FORWARD ON MANY FRONTS DURING THE REVIEW PERIOD. BY WAY OF CONCLUSION, WE OFFER THE FOLLOWING OBSERVATIONS:

- The highlights given in Chapter 2 provide solid evidence that our R&D programs deliver valuable products and services to our clients in DND and the Canadian Forces.
- We have met or exceeded the five Key Objectives established for DRDB for 1999/2000.
- Our success rate on Client Group Major Initiatives is fully satisfactory.
- Our performance in achieving milestones is improving. In 1999/2000, we had a 76% achievement rate on a total of 377 milestones, as compared to a 66% achievement rate in 1998/1999. We also see evidence of a better understanding of what should constitute a milestone and greater consistency in the relationship between resource expenditure within a CG and the total number of milestones in a year.
- We made significant contributions on a number of S&T policy issues.
- Our level of involvement with national S&T partners is growing. Leveraging and revenue generation are on target, the Defence Industrial Research Program continues to be very successful, and the DND/NSERC Research Partnership Program is off to a good start.
- There is a healthy level of technology transfer from DRDC to Canadian industry. Table 9 provides many examples of patents, reports of invention and licensing agreements.
- We derive excellent value from our international linkages. We have promised DND that we will leverage $40M from international allies by 2004, and we expect that we will exceed this target by a comfortable margin.
- Our productivity in terms of publications and presentations is fully satisfactory.
- The two peer reviews that we conducted in 1999/00 showed that we have strong technical teams in Radar and Navigation Technology at DREO and Command and Control Technology at DREV.

We have successfully converted the Defence R&D Branch into an Agency – Defence R&D Canada. Agency stand-up has been accompanied by the launch of many corporate initiatives – in technology investment, program management, business development and human resources. We will track progress on these initiatives in future Annual Reports.

Tables

Table 1 – Scientific Capabilities of Defence Research Establishments

DREA	• Sonar sensors and undersea environmental acoustics • Naval and airborne sonar technologies • Electromagnetics • Marine materials • Ship operability, safety and signatures • Mine and torpedo countermeasures • Naval command and control
DREV	• Advanced electro-optical systems • Military laser technology and systems • Remote sensing technology and systems • Acoustic surveillance systems • Electromagnetic sensor performance prediction • Information systems technology • Weapon effects • Weapon delivery systems • Energetic materials
DREO	• Aerospace radar and navigation • Surface radar • Electronic warfare – electronic support measures • Electronic warfare – electronic countermeasures • Military communications • Space systems technology • Information operations • Radiation biology and radiation detection
DCIEM	• Human engineering • Simulation and training technologies • Information processing • Human protection and performance • Aerospace life support • Biomedical sciences • Air vehicles • Experimental diving
DRES	• Detection and identification of chemical and biological (CB) agents • Physical protection against CB agents • Medical countermeasures against CB agents • Countermine technology • Threat assessment and explosive effects • Tactical vehicle mobility and robotics

Table 2 – Defence R&D Branch 1999/00 Resource Summary

EXPENDITURES BY FUND TYPE AND SITE ($K)

	Salary	Local O&M	R&D Contracts	Equipment	Total
DREA	11,198	2,652	5,197	2,949	21,996
DREV	17,910	6,866	13,313	11,586	49,674
DREO	8,483	2,939	14,070	8,579	34,070
DCIEM	7,549	2,290	10,768	4,922	25,529
DRES	8,906	4,140	6,014	3,445	22,505
HQ	5,301	2,373	40,055	9,193	56,922
Total	**59,346**	**21,260**	**89,416**	**40,674**	**210,696**

SOURCES OF REVENUE BY SITE ($K)

	Private Sector Sources	OGD's	Intellectual Property	Total
DREA	68			68
DREV	1,470			1,470
DREO	221	246	300	767
DCIEM	675	148		823
DRES	313	49		362
HQ	57		1,200	1,257
Total	**2,804**	**443**	**1,500**	**4,747**

CIVILIAN FTE'S BY GROUP

	FTE's	# Hired	# Departed
Defence Scientists	379	28	14
Other Professionals	51	4	2
Technologists	275	4	17
Executives	2		
Administrative Staff	234	10	16
Operational Staff	108	8	4
Total	**1,049**	**54**	**53**

Total Number of Military FTE's – 35

Table 3 – Defence R&D Activities

Autonomous Intelligent Systems

- Method for AIS to perceive its environment
- Intelligent planning & control systems for AIS to interact with its environment
- AIS fusion with the overall C2 system

Chemical/Biological/Radiological Threat Assessment and Detection

- Threat assessment and consequence management
- Detection, identification and diagnosis
- Individual and systems protection

Command & Control Information Systems

- Techniques to assure C2IS interoperability
- Intelligent systems technologies for distributed information processing
- Application of measures of merit to optimum information systems exploitation
- Exploitation of object oriented technology for optimized software development

Communications

- Military bandwidth on demand
- Military communications system assured quality of service
- Intelligent management of network resources for the integrated battlefield
- Communications enablers for distributed systems

Electro-Optical Warfare

- Multiband threat detection, identification, localization and tracking
- Directional EO/IR countermeasures
- "Plug & Play" mission-configurable self-defence systems

Emerging Materials and Bio-Molecular Technologies

- Functional materials for transducers, actuators and smart structures
- Substitution of conventional materials by tailored polymers
- Synthesis of military materials by molecular manufacturing techniques

Human Factors Engineering and Decision Support

- Models of operator workload, human performance, and function allocation
- Theories and models for human-computer interaction and crew systems
- HFE design tools
- Multidimensional information presentation systems for decision support
- Decision aids for multiple criteria and objectives
- Commercial technology exploitation for effective operator machine interaction

Information and Knowledge Management

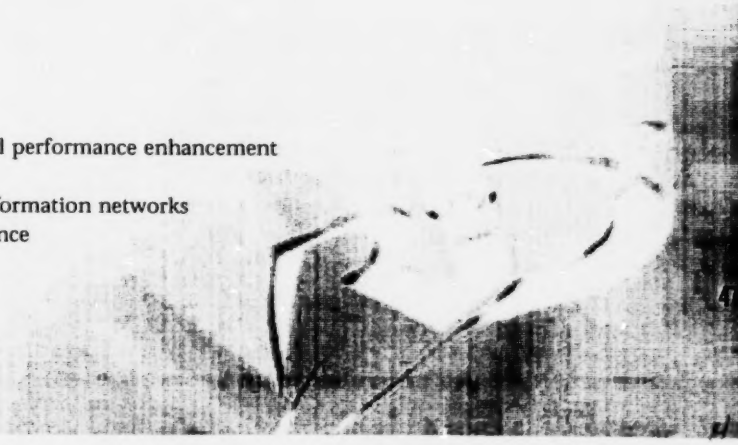
- Machine learning
- Knowledge modelling
- High level data fusion
- Multidimensional spatial-based systems
- Organizational dynamics

Multi-Environmental Life Support Technologies

- Life support technologies
- Occupational health hazards
- Automated 'smart' protection
- Environmental threats, countermeasures and performance enhancement

Network Information Warfare

- Detection and analysis of soft attacks on information networks
- Network protection and information assurance
- Exploitation of information networks



Defence R&D Activities continued

Operational Medicine

- Casualty management and diagnostics
- Toxicology and pharmacology
- Prevention and treatment of disease

Platform Performance and Life Cycle Management

- Extension of computational fluid dynamics to complex vehicle configurations and extreme flows
- Structural analysis for life-cycle management and insertion of advanced materials technology
- Extension of aero-propulsor performance and life-cycle
- Materials and materials management for platform and systems safety and life-cycle management
- Modelling of operational limits and safety for military platforms and embarked systems

Precision Weapons

- High-performance propulsion systems and propellants
- Automated fire and trajectory control
- Precise targeting
- Assessment of weapon precision and effectiveness through simulation

Psychological Performance

- Leadership development
- Problem solving, bounded reasoning and reasoning under uncertainty
- Command stress and coping
- Multicultural team performance

RF Electronic Warfare

- Forecasting and response to emerging EW threats
- Multidimensional high fidelity sensing and surgical EW response
- Automated EW situation interrogation, assessment and response

Sensing (Airspace and Surface)

- Exploiting environmental knowledge for target discrimination and recognition
- Full EM spectrum sensing of camouflaged and small targets
- Autonomous systems for remote surveillance
- All weather surveillance systems for low observable targets
- Sensor disparity and diversity exploitation
- Reduced cross-section focal plane arrays
- Sensor exploitation and integration for landmine detection

Sensing (Underwater)

- Affordable distributed sensors and influence sweeps
- In-situ sensing of oceans and seabed properties
- Timely provision of the UWW tactical picture

Signature Management

- Underwater signature prediction and reduction
- Surface and air signature prediction and reduction
- Integrated signature management
- Reduced signatures for explosive ordnance disposal
- Underwater decoy systems

Defence R&D Activities continued

Simulation and Modelling for Acquisition, Rehearsal and Training (SMART)

- Live, virtual, and constructive simulations
- Development, validation, verification and accreditation of physics-based models and data sets
- Development, validation, verification and accreditation of models of human behaviour
- Distributed simulation and modelling
- Representation of operational scenarios

Space Systems

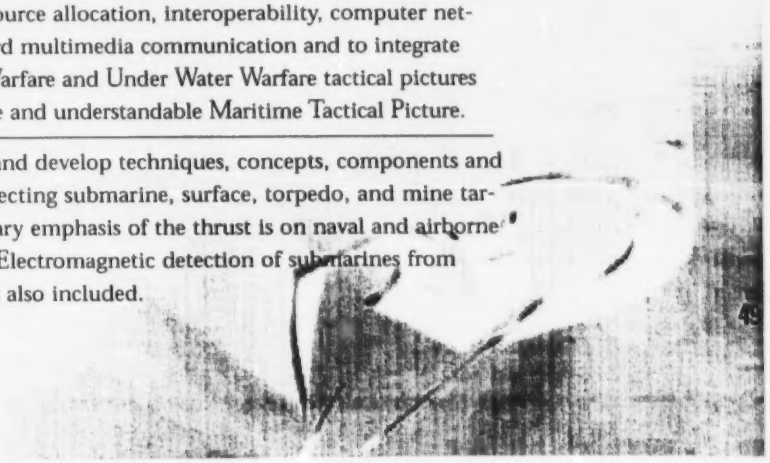
- High fidelity M&S tools for performance evaluation, concept analysis and development
- Space-based early warning and defence
- Survivable leading edge electronics for harsh space environments
- Sensing, tracking and identification of space objects

Weapons Effects

- Novel energetic materials
- Assessment of hypervelocity penetrators
- Weapon systems effectiveness
- Non-nuclear EMP and RF weapons
- Life cycle management
- Countermine breaching, destruction, neutralization and protection

Table 4 – R&D Thrusts

Thrust	Objectives/Scope
	Maritime
1.a Maritime Integrated Above Water Warfare	To develop new techniques in sensor signal and data processing, investigate systems integration concepts and improve individual technologies of sensors, weapons and countermeasures associated with above water warfare.
1.b Maritime Command, Control, Communications and Intelligence	To enhance the effectiveness of commanders ashore and at sea by improving command's ability to manage data and information from all sources. More specifically, to develop cost-effective solutions in key areas such as local and wide area data fusion, situation assessment, resource allocation, interoperability, computer networks, shipboard multimedia communication and to integrate Above Water Warfare and Under Water Warfare tactical pictures into an accurate and understandable Maritime Tactical Picture.
1.c Maritime Underwater Warfare	To investigate and develop techniques, concepts, components and systems for detecting submarine, surface, torpedo, and mine targets. The primary emphasis of the thrust is on naval and airborne sonar systems. Electromagnetic detection of submarines from ASW aircraft is also included.

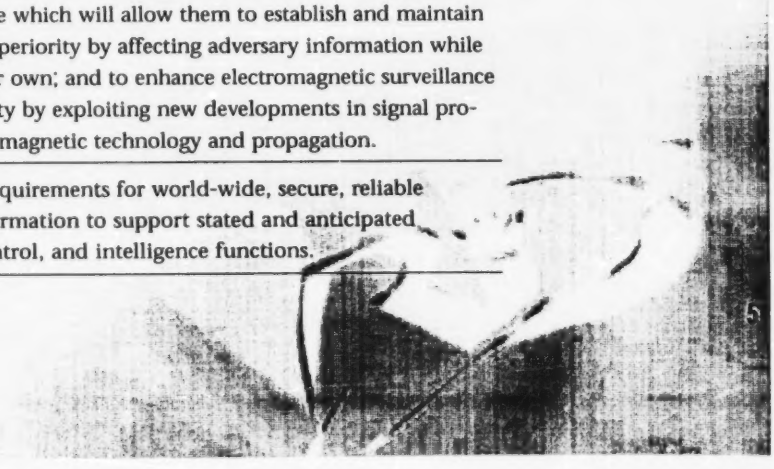


R&D Thrusts continued

1.d Maritime Mine Countermeasures Systems	To counter the mine threat to CF vessels by advancing the state of the art in route surveying, mine hunting, mine identification, mine avoidance and ship silencing.
1.g Naval Platform Technology	To maximize Canadian Maritime Forces operational effectiveness and safety by reducing underwater acoustic signatures, improving structural integrity, and establishing safe ship and submarine operational envelopes. To minimize construction, operating and maintenance costs by applying new platform and materials technology to Canada's naval fleet.
	Land
2.c Soldier Systems	To meet the army's S&T needs in soldier systems, including: lethality, survivability, mobility, sustainment, command, control, communications, and human performance.
2.f Tactical Vehicle Systems	To meet the army's S&T needs for tactical vehicle systems, including: mine blast protection, active/reactive armour, defensive aid suites, unmanned vehicles, vehicle technologies, and advanced land fire control systems.
2.k Information Operations	To meet the army's S&T needs in support of information operations, including: surveillance, target acquisition, night observation, EW, command and control information systems, tactical communications and countermeasures, and counter-surveillance.
2.m Military Engineering	To meet the army's S&T needs in combat engineering, including: counter-mobility (demolition systems), mobility (countermine), and formation-level protection.
2.n Munitions & Firepower	To meet the army's S&T needs for weapon systems, including: direct and indirect fire weapons, directed energy weapons, munitions life cycle management, energetic materials, combustion processes, and terminal effects.
	Air
3.a Air Force Operational Information Management	To explore, develop and demonstrate advanced technologies that can be applied to command, control and intelligence systems to enhance air force effectiveness during normal, deployed, and contingency operations.

R&D Thrusts continued

3.c Air Electronic Warfare	To enhance the self-defence capabilities of CF aircraft through investigations in and application of four primary technologies: threat assessment (signatures, characteristics, vulnerabilities); threat detection and identification; sensor fusion and data processing; and soft-kill response (jamming, dazzling, decoys, manoeuvres, etc).
3.d Airborne Surveillance	To explore, develop, and demonstrate advanced technologies and their application to effective surveillance and target acquisition capability of airborne platforms. Emphasis will be placed on the integrated approach to achieve an effective impact on mission success.
3.e Air Weapons Systems	To provide advice and scientific support to assist the Air Force with the selection of new weapon systems and to extend the life and effectiveness of existing systems. This includes R&D in aerodynamics, propulsion, energetic materials, and simulation and modelling.
3.g Air Vehicles	To maintain and enhance the capability and safety of CF air platforms and engines through R&D in: structures and materials; aerodynamics and flight mechanics; propulsion; and electrochemical power sources.
3.i Aircraft Crew-system Technologies	To assist the Air Force in understanding and applying advances in crew-system technologies. To show improvements in mission effectiveness and flight safety by demonstrating advanced crew-station and human protective/performance enhancing systems.
	Command and Control Information Systems
5.a National Level Command and Surveillance	To provide solutions to meet current and future CF requirements for national level command and control functions. This includes the capability to develop and present the national common operating picture and to improve the associated strategic wide-area surveillance systems.
5.b Information Warfare	To ensure the CF and DND have assess to technologies and technical advice which will allow them to establish and maintain information superiority by affecting adversary information while protecting their own; and to enhance electromagnetic surveillance and survivability by exploiting new developments in signal processing, electromagnetic technology and propagation.
5.c Military Information Technology Infrastructure	To meet CF requirements for world-wide, secure, reliable passage of information to support stated and anticipated command, control, and intelligence functions.

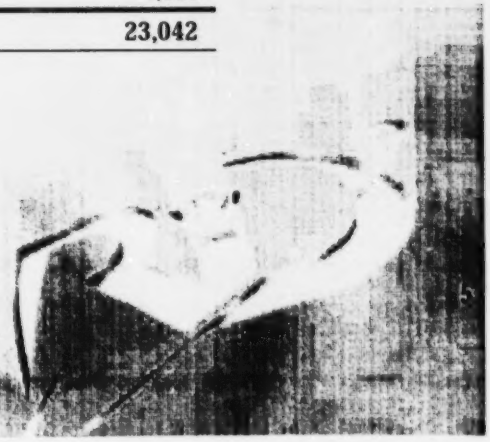


R&D Thrusts continued

5.e Space Systems and Technologies for Defence Applications	To support DND space policy objectives through the development of capabilities in: space systems and technologies; space environment and electronics; space-based surveillance; and surveillance of space.
	Human Performance
6.b Simulator Training Technologies	To maximize combat readiness and job performance, while minimising costs, environmental damage, and risk to personnel safety.
6.c Military Operational Medicine	To enhance the CF's capability to assess and prevent health hazards; to prepare for and sustain the delivery of deployed health care; and to prevent, diagnose, treat and manage illness and trauma arising from conventional military operations.
6.i Diving & Underwater Intervention	To enable the development and acquisition of effective diving equipment and procedures for operational roles such as MCM, search & rescue and land combat engineering. To reduce injury and death of personnel in hyperbaric environments. To optimize the use of divers and ROVs/AUVs/robotics systems. To increase security and availability of the fleet, selected army units, and Joint Task Forces.
6.k Human Factors in Military Systems	To support DND in the acquisition and operation of effective manned systems through R&D activities that: provide a better understanding of human decision-making; develop models of human capabilities and limitations; support the acquisition or modification of effective human-machine systems and equipment; and develop effective human engineering tools and techniques to support DND projects.
6.q Defence Against Chemical, Biological and Radiation Hazards	To conduct R&D leading to improved hazard assessment tools for field commanders, better detection systems, effective medical pre-treatments and therapies, improved decontamination equipment, and less burdensome personal protective equipment
	S&T Policy and Advice
20.a Technology Outlook	To look out for emerging technologies and assess their potential relevance to Canadian defence.
20.b Scientific and Technical Intelligence Advice and Support	To enable DRDC to provide timely and high-quality scientific and technical intelligence support and advice for the Department.
20.c S&T Services for Operations	To provide regular consultation services to the CF/DND that draw on DRDC's S&T expertise and facilities (e.g. Dockyard Laboratory support).

Table 5 – 1999/00 Expenditures by Client Group and Thrust

Business Line / Client Group / Thrust		Civilian FTE's	Total Expenditure ($K)
Business Line 1			
Maritime Client Group			
1.a	Maritime Integrated Above Water Warfare	25	7,562
1.b	Maritime Command, Control, Communications and Intelligence	17	5,733
1.c	Maritime Underwater Warfare	55	8,340
1.d	Maritime Mine Countermeasures Systems	15	2,334
1.g	Naval Platform Technology	34	6,174
Total Maritime		**146**	**30,143**
Land Client Group			
2.c	Soldier Systems	18	3,866
2.f	Tactical Vehicle Systems	32	6,458
2.k	Information Operations	28	8,254
2.m	Military Engineering	10	2,666
2.n	Munitions and Firepower	23	4,240
Total Land		**110**	**25,484**
Air Client Group			
3.a	Air Force Operational Information Management	10	1,679
3.c	Air Electronic Warfare	17	4,465
3.d	Airborne Surveillance	29	5,304
3.e	Air Weapons Systems	19	2,174
3.g	Air Vehicles	5	4,901
3.I	Aircraft Crew-system Technologies	13	4,519
Total Air		**93**	**23,042**



Command Control Information Systems Client Group			
5.a	National Level Command and Surveillance	26	4,245
5.b	Information Warfare	28	5,734
5.c	Military Information Technology Infrastructure	10	8,290
5.e	Space Systems and Technologies for Defence Applications	25	8,829
Total CCIS		**88**	**27,098**
Human Performance Client Group			
6.b	Simulator Training Technologies	7	1,799
6.c	Military Operational Medicine	12	2,266
6.I	Diving and Underwater Intervention	7	1,055
6.k	Human Factors in Military Systems	19	2,470
6.q	Defence against Chemical, Biological and Radiation Hazards	60	11,256
Total HP		**104**	**18,846**
Total Business Line 1		**542**	**124,613**
Business Line 2			
20.a	Technology Outlook	11	647
20.b	Scientific and Technical Intelligence Advice and Support	7	405
20.c	S&T Services for Operations	16	927
Total BL 2		**35**	**1,979**
Business Line 3		**27**	**1,498**
Business Line 4			
7.a	Management and Administration	178	19,653
7.b	Central Technical Support	167	19,467
7.c	Site Support	87	11,251
Total BL 4		**433**	**50,371**
Departmental and Interdepartmental Initiatives		14	3,803
Opportunity Funds			28,430
Agency Totals		**1,050**	**210,696**

Table 6 – Technology Demonstration Projects

Project Name	Start Date	End Date	Total $ K	99/00 $ K
Advanced Land Fire Control System	1990	2000	9,842.0	1,783.0
Canadian Naval Electronic Warfare Set	1990	2002	31,604.0	1,107.8
Artillery Regimental Data System	1992	2001	22,561.0	770.0
Towed Array Sensor Development	1993	2003	10,792.0	120.0
Synthetic Aperture Radar	1993	2004	6,654.0	340.0
Advanced Shipboard Command and Control Technology	1995	2000	6,350.0	1,648.0
HF Surface Wave Radar for Coastal Surveillance	1995	2001	6,352.0	349.6
Qualification Methodologies for Gas Turbine Repair	1996	1999	5,680.0	200.0
Next Generation SHINCOM (SHINCOM II)	1996	2002	7,238.0	768.0
Improved Ship Structural Maintenance Management	1996	2004	4,290.0	587.0
Soldier Information Requirements	1996	2004	16,398.0	484.0
EHF SATCOM	1996	2000	2,500.0	85.0
Canadian Integrated Biological Agent Detection System	1996	2000	9,203.0	1,288.0
Next Generation Signal Processor*	1997	2001	7,909.0	4,000.0
Towed Integrated Active/Passive Sonar	1997	2004	12,140.0	1,690.0
Remote Mine-hunting System	1997	2004	8,677.0	266.0
Vaccine Development Initiative	1998	2004	4,997.0	295.5
MILSATCOM Performance Enhancement	1998	2001	8,088.0	4,224.0
Enhanced Synthetic Vision System	1998	2001	3,100.0	1,030.0
Land Intelligence and Electronic Warfare Automation	1998	2003	6,374.0	1,475.0
Pyrophoric IR Decoy/Dispenser	1998	2001	7,015.0	2,093.0
Electronic Warfare Technology Demonstrator	1998	2001	5,931.0	309.0
Tactical Aviation Mission System Simulation	1999	2004	6,100.0	80.0
Future Armoured Vehicle Systems	1999	2004	8,000.0	160.0
Common Operating Picture	1999	2004	6,120.0	200.0
Space-Based Radar GMTI	1999	2004	7,290.0	3,616.0
Advanced Distributed Mission Training	1999	2003	8,017.0	60.0
Weapons Technology Evaluation	1999	2005	916.0	546.0
Total				**29,574.9**

*Note: The funds originally allocated to this project have been transferred to the Navy's SIRIUS project for procurement of an alternate signal processor.

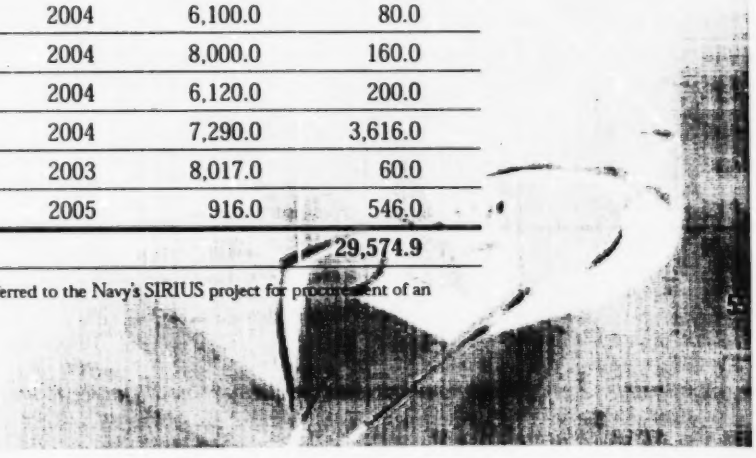
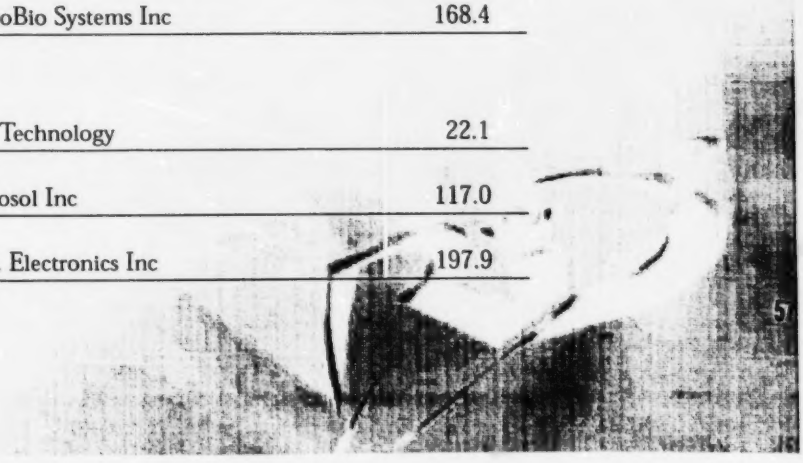


Table 7 – Technology Investment Fund Projects

Project Name	Start Date	End Date	Total $ K	99/00 $ K
JMCIS-Based Sonar Information Management	1998	2002	810.0	260.0
Electromagnetic Radiation Munitions (DREV)	1998	2002	489.0	280.0
Electromagnetic Radiation Munitions (DREO)	1998	2002	511.0	70.0
FOREX – DRES	1998	2001	1,000.0	300.0
FOREX – DREV	1998	2002	850.0	300.0
Laser Beamrider Detection System	1998	2001	650.0	250.0
Detection of Malicious Codes in COTS Software	1998	2002	520.0	180.0
Mobile Communications EW Countermeasures	1998	2002	900.0	329.0
Integrated Physiological Modelling	1998	2001	360.0	100.0
DNA Immunisation to BW Agents	1998	2001	1,000.0	370.0
Rapid Production of Genetic Engineered Human Antibodies for Immunotherapy and Diagnostics	1998	2001	920.0	350.0
Mid-Infrared Active Imaging MAWS/Dazzler	1999	2002	690.0	170.0
Intelligent Recognition System for Sensor Surveillance	1999	2002	280.0	80.0
Space-Time Adaptive Processing: Algorithm Design and Implementation for Airborne Radars	1999	2001	450.0	57.0
Helmet Mounted Fused IR/II for Enhanced Night Vision	1999	2002	875.0	185.0
Miniaturization of EHF T/R Modules for Phased Arrays	1999	2002	650.0	190.0
Self-Organized Goal-Driven Adaptive Learning	1999	2002	560.0	170.0
Stand-off Biodetection	1999	2002	725.0	460.0
Total				**4,101.0**

Table 8 – Defence Industrial Research Projects in 1999/00

DIR Project Title	Firm	99/00 $K
Signal Image and Data Processing Algorithms	A.U.G. Signal Ltd	247.2
CFD Prediction of the Flow Around Ships	AEA Technology Engineering Software Ltd	106.9
Cultured Human Skin for Burn and Wound Therapy	Apotex Research Inc	78.4
Tools for the Generation of Advanced ScanSAR Data Products with RADARSAT	Atlantis Scientific Inc	144.2
Research into Piezoelectric and Electrostrictive Materials for Use in Smart Structures	B.M. Hi-Tech Inc	40.3
Low Frequency Acoustic Transducers	B.M. Hi-Tech Inc	114.9
Immune Modulator Strategy Phase II	Biophage Inc.	253.7
Development of Advanced Navier-Stokes Methods for Vortical and Separated Flows	Bombardier Aerospace	97.2
Technology Development for the Gyrowheel Spacecraft Attitude Control Device	Bristol Aerospace	60.6
ESM Against Modern Military Communications	Calian Technology Services	153.6
Instructional Systems Engineering and Delivery	Cogigraph Technologies Inc	462.7
Direct View Thin Film Electroluminescent Enabling Technology for Military Display Applications	Computing Devices Canada	292.0
Tactical Multimedia over Wireless and Wired LANs	Computing Devices Canada	334.8
Proof-of-Concept for a Hand-Held Real Time Biodetector and Sampler	Computing Devices Canada	86.4
Radiation Hardened Startracker Research Project	EMS Technologies Canada (formerly CAL Corp)	56.2
Enzyme-based Bioreactor for Carbon Dioxide Management in Submarines	EnviroBio Systems Inc	168.4
Prototype Alternating Current Potential Difference System to Measure Compressive Residual Stresses in Metallic Components	Fleet Technology	22.1
Orthopedic and Cardiac Clinical Trials with Hemolink in Surgery	Hemosol Inc	117.0
Advanced Agile Frequency Sources for Defence Applications	I.T.S. Electronics Inc	197.9



Defence Industrial Research Projects in 1999/00 continued

Biosensors for Detection/Identification of Chemical and Biological Warfare Agents	IatroQuest Corporation	166.8
Low-Cost Panoramic Video Surveillance System	IMAGO Machine Vision Inc	314.6
Hyperspectral Land Mine Detection	Itres Research Limited	163.3
Inorganic Intumescent Coating Technology for Improved Fire Safety on Naval Vessels/Submarines	J.O. Bernt & Associates	4.5
Image Analysis and Object Recognition Decision Aids for Airborne Surveillance	Lockheed Martin Canada	230.6
Magneto-Inductive Duplex Communication System	Magneto-Inductive Systems Ltd	121.1
Mine Boot Protection System	Med-Eng Systems Inc	37.3
Water Activated Foam for Cold Water Immersion Garments	Mustang Survival Corporation	12.3
Recombinant Spider Dragline Silk-based Ballistic Protection	Nexia Biotechnologies Inc	404.0
X-Band Multifunction MMIC	Nortel Networks	193.1
HBT Power Cell Development	Nortel Networks	408.3
Distributed Parallel Simulation Server Compatible with Simulink and RT-Lab	OPAL-RT Technologies Inc	414.1
HVOF Process Development, Evaluation and Qualification	Orenda Aerospace Corporation	278.4
Optimization of the Mechanical Characteristics of Nanocrystalline, Superplastic Formed Zirconia Toughened Alumina	Pacific Safety Products Inc	82.6
Digital Elevation Model Extraction from RADARSAT SAR Stereo Imagery	PCI Enterprises Inc	11.9
Seabed Classification for Multibeam Sonars	Quester Tangent Corporation	199.6
Evaluation of IM Technology for the Large Calibre Ammunition	SNC Technologies Inc	32.1
Integrated Ship Defence Simulation Research and Development	Tactical Technologies Inc	14.6
Research into Synthesis of Ultra-Fine Metallic Powders	Tekna Plasma Systems Inc	198.3
Advanced Degaussing Unit	W.R. Davis Engineering Ltd	13.6
Total		**6,335.6**

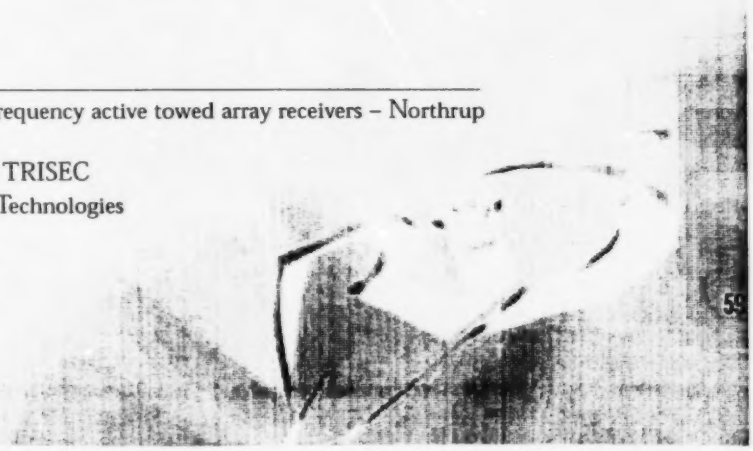
Table 9 – Technology Transfer – Patents, Reports of Invention and Licenses

Patents and Reports of Invention

- Inexpensive oil-in-water monitor to indicate the amount of oil contamination in water
- Technique called CRABCLAD utilizing chromium-modified nickel-aluminum bronze for weld cladding or repair of corroded components
- Sun optical limitation illuminator detector
- Synthesis of energetic thermoplastic homopolymers and energetic thermoplastic elastomers
- Gaine d'enroulement de câblage
- Synthesis of nanotubes and nanofibres
- Automatic gain control for digital radar intercept receivers
- Forced air warming system, torso heating vest
- Delivery of liposomal antioxidants for therapeutic applications
- Hydrogel wound dressing containing liposome-encapsulated therapeutic agents
- Pulmonary delivery of liposome-encapsulated tetrahydrocannabinol
- Method for measuring blood pressure under noise and vibration intense environments
- Emergency exit system
- Method for tracing organ motion & removing artifacts for tomography imaging systems
- High resolution 3D ultrasound imaging system deploying multi-dimensional array sensors
- Acoustic tomography system for detection & volumetric analysis of immersed objects
- Use of liposome encapsulated ciprofloxacin as an immuntherapeutic drug
- Aerosol delivery of liposome-encapsulated fluoroquinolone
- Polysaccharide vaccine to enhance immunity against brucellosis
- Use of virulence factors of pathogens to improve liposomal delivery of antibiotics and/or vaccines
- Vaccine against pneumonic plague
- Liposome-encapsulated poly icic
- Liposome-encapsulated ciprofloxacin
- Bacterial and synthetic polysaccharide immunomodulators that enhance general immunity
- Method of detecting a pathogen using a virus
- Combination vaccine for enhancing immunity against brucellosis
- Low burden integrated chemical protective hood for use with helmets
- Foam formulations
- Broad spectrum decontamination formulation and method of use
- Decontaminating and dispersion suppressing foam formulation
- Articulated robotic scanner for mine detection
- Solar infrared ground clutter suppressor
- Land mine destroying & disabling system

Licensing Agreements Completed

- Resolved directional sensor for use in low frequency active towed array receivers – Northrup Grumman Canada
- Fatigue and fracture educational software – TRISEC
- Biometric authentication systems – Labcal Technologies
- Telweb – Schlumberger
- Electronic Battle Box – Australian Army



Technology Transfer – Patents, Reports of Invention and Licenses

- Spotlight synthetic aperture radar technology – MacDonald Dettwiler
- Associative memory integrated circuit – Newbridge Microsystems
- Microwave technology – Telemus Inc.
- Repetitive electrodeposition of lithium – Research & Productivity Council of New Brunswick
- DFACTT and EW battlefield simulator – Software Kinetics
- Matlab simulation SBRSIM – Sicom Systems
- Degrad monitor technology – Sicom Systems
- High speed sharc link port communications interface – Transtech DSP Corporation
- Intelligent clothing and equipment sizing system – VisImage Inc
- Aircrew cockpit crew station demonstrator – Canadian Marconi
- Crew Resource Management Instructional Module – University of Toronto
- Liposomal hydrogel coatings – UroTeq
- Canister – 3M
- Vital signs monitoring technology – CANAMEX
- Canadian Aqueous System for CB Agent Decontamination – Irvin Aerospace Canada

Licensing Agreements Pending

- Structural analysis software – MARTEC
- Fire-fighting foam analysis tool (PHASAR) – MARENTEC
- Transducer modelling software (MAVART) – Sensor
- Next generation signal processing software toolkit – AMIRX
- Folded shell projector (FSP) design for an in-air speaker – Edge Technologies
- FSP design for underwater applications – in competition
- Horizontal projector array (HPA) design for low frequency active sonars – Hermes
- LUCIE – SATLANTIC
- Photon irradiance meter – Technologies Lyre
- CASE-ATTI – several organizations
- Bolometers – INO
- ADRAS (Armour Data Recovery and Analysis System) software – Bosik Consultants
- Pyrophoric decoy flare technology – Bristol Aerospace
- Laser beam, laser dazzling and HARLID integrated system – Litton
- Geographic Information System – Global Géomatique
- Shipborne Infrared Maritime Parameter Lidar Equipment related to multi-field-of-view – Optec
- ACIDE database – DMS Technologies
- LETOPS – Dew Engineering
- Thin film thermophile detectors – Gentec Électro-Optique
- Liposomal antioxidants and alkaloids – Delex Inc
- DCIEM cold exposure survival model – DSSI
- Helicopter escape system – Survival Systems
- Carbon impregnated lycra

Table 10 – Examples of Revenue Generation Projects

DREA

- Provide acoustic signature predictions of autonomous semi-submersible marine vehicle
- Use of DASS finite element modelling system for ship structures
- Develop MAD tactical decision aids
- Investigate the corrosivity of a commercial paint stripper
- Provide acoustic modelling support and consulting advice for sonar performance evaluations & predictions

DREO

- Space radiation effects on electronics & materials
- Tracker tests
- Battlefield & low-level radiation testing
- New electronics materials studies
- Radiation detector evaluation
- Low-level radiation health effects
- SAR consulting
- Simulation modelling
- EMP testing
- SRTM shuttle
- Radar upgrade

DCIEM

- Specialist occupational health consultations
- Forensic analysis in diving accident investigation
- Vaccine storage & distribution for the CF
- Emergency survival equipment for the NATO FTC Harvard II aircraft
- Impact facility testing of vehicle personal restraint systems (16 different manufacturers of car seats and restraint systems)
- Aircrew life support (HAWK aircraft) – OBOGS high altitude performance
- Tactical decision making under stress
- Novel anti-nausea medications
- Crew resource management – human factors instructional module
- Prevention of decompression sickness in astronauts during prolonged EVA's
- Simulated angle of impact (helicopter crash) – underwater emergency escape
- Diving & aircrew medicine courses
- Identification of personal flotation devices
- Embedded microprocessor-based tomography
- Bactericidal efficacy of pharmacological agents
- Analysis techniques for engineering anthropometry
- Head-mounted eyewear system studies
- Test & evaluation of smoke detectors
- Environmental evaluation of ski ensemble prototypes
- Spatial disorientation countermeasures

Examples of Revenue Generation Projects continued

DREV

- Development of a 105-mm visual and infrared screening smoke round
- Vibration testing of lithium batteries
- Development of a low vulnerability gun propellant
- Development of a new gas generator for use in inflating third-generation automotive air bags
- Army Tactical Command and Control Information System (ATCCIS) proof of concept
- Service life assessment of military munitions
- Field evaluations of Visual and Infrared Screening Smoke (VIRSS) grenades
- Development of Propagation Resources in Maritime Environments (PRIME) software for the evaluation of ship-borne infrared sensors
- Modelling and evaluation of crew survivability in light armoured vehicles in the presence of anti-tank landmines
- Identify information fusion impact of STANAG 4162
- Temperature and humidity cyclical testing of prototype extended-range 105-mm munitions
- Under the TRUMP Threat Evaluation and Weapons Assignment (TEWA) Project, development of a threat evaluation algorithm for application to Iroquois-class ships
- Aeroballistic range tests of 40-mm projectile configurations flying at 65 m/s
- Design of a protection system for military 4x4 vehicles against 1-kg and 6-kg landmines
- Field evaluations of prototype and operational laser irradiation warning systems
- Development and implementation of a National Infrastructure Data Base (NIDB) in preparation for the Y2K bug
- Technical training associated with the technology transfer of superconductor thermopiles
- Technology transfer of the Auto Context Image Database Exploitation (ACIDE) system
- Modelling of spatial knowledge and awareness for use in a navigation context
- Development of an intelligence information system in support of the Joint Command and Control Information Systems (JC2IS) Project

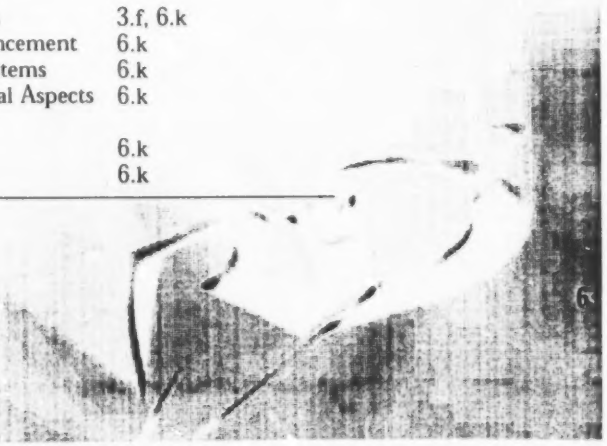
DRES

- Drug delivery development.
- Oligonucleotide therapy research and development
- Trial support – biological detector assessment
- Development of aerosol dissemination models
- Scientific consultation – chemical neutralization processes
- Mechanism of action of sulphur mustard toxicity
- Evaluation of chemical agent protection of fabrics
- Access to use of vapour facility
- Access to range for explosive trials
- Performance of chemical agent penetration tests
- Use of field and laboratory aerosol testing facilities
- Access to range for warhead proofing
- Access to bio-containment 3
- Provision of first responder course
- Provision of training for CB counter-terrorism units

Table 11 – Prominent International Activities

The Technical Cooperation Program

Group	Technical Panels & Action Groups	Affected Thrusts
Aerospace Systems	• Helicopter Aerodynamics, Dynamics & Man-Machine Integration	3.g
	• Propulsive & Mechanical Systems, Condition Monitoring & Diagnostics	3.g
	• Structures & Aerodynamics of Aeronautical Vehicles	3.g
	• Combat Aircraft Aerodynamics	3.g
	• UAV Systems Technologies	2.k,3.d
	• Space Systems & Technologies	5.e
	• Air Systems Simulation & Modelling	3.e,3.f,3.g
	• Certification of Bonded Structures	3.g
Command, Control, Communications & Information	• Space & UAV Communications Technology	5.e
	• Networking & Communications Technology	1.b,2.k,3.a,5.a
	• C2 Systems Application Technology	1.b,2.k,3.a,5.a
	• Distributed Information Systems Technology	1.b,2.k,3.a,5.a
	• Information Assurance & Defensive Information Warfare	5.b,5.c
	• Information Fusion	1.b,2.k,3.a,5.a
Chemical, Biological & Radiological Defence	• Medical Countermeasures against Biological Agents	6.q
	• Hazard Assessment	6.q
	• Detection of Biological Agents	6.q
	• Low Burden CB Individual Protective Equipment	6.q
	• Chemical Toxicology	6.q
	• Gene Probes	6.q
	• Radiological Hazards	6.q
	• Passive Stand-off Chemical Detection	6.q
	• BTWC Related Analytical Methodologies	6.q
Electronic Warfare Systems	• Countermeasures to Advanced & Coherent Threats to Air Platforms	3.c
	• Communications EW	1.a,2.k,3.c
	• Countermeasures to Surveillance & Targeting Radars	1.a,2.k,3.c
	• Electronic Support Measures	1.a,2.k,3.c
	• EO & IR Warning & Countermeasures	1.a,2.k,3.c
Human Resources & Performance	• Training Technology	6.b
	• Military Human Resource Issues	6.k
	• Physiological & Psychological Aspects of Using Protective Clothing	2.c,6.k,6.q
	• Human Factors in Aircraft Environments	3.f, 6.k
	• Physical & Cognitive Performance Enhancement	6.k
	• Human Factors Integration for Naval Systems	6.k
	• Nutritional, Physiological & Psychological Aspects of Using Combat Rations	6.k
	• Survival Psychology	6.k
	• Command Team Performance	6.k



Prominent International Activities continued

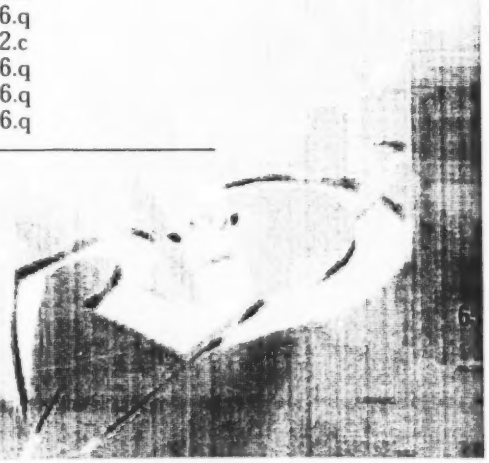
Joint Systems & Analysis	• Land Systems	2.c,2.f,2.k
	• Modelling & Simulation	Various
	• Simulation-based Acquisition Process	6.k
	• Wide-Area Surveillance/Recognized Picture	3.d,5.e
	• UAV Concepts	2.k,3.d
Maritime Systems	• Data Integration for Maritime Warfare	1.b
	• Maritime Warfare Studies	1.a,1.c
	• Sonar Technology	1.c
	• Airborne Sensor Technology	1.a,1.c
	• Mine Warfare & High Frequency Acoustics	1.d
Materials Technology & Processes	• Metals Technology & Performance	1.g,3.g
	• Non-Destructive Evaluation for Ageing Military Platforms	1.g,3.g
	• Polymers, Adhesives & Coatings	1.g,3.g
	• Composites Technology & Performance	1.g,3.g
	• Technologies for Enhancing Individual Combatant Protection	2.c
Sensors	• Multi-Sensor Integration	1.a,2.k,3.d,5.e
	• Signal/Image Processing	1.a,1.c,2.k,3.d
	• Radar Systems & Technology	1.a,2.k,3.d,5.e
	• EO Sensor Systems	1.a,2.k,3.d,5.e
	• Technology of Laser Systems	1.a,1.c,2.k,3.d
	• Radar Detection of Small Targets in Clutter	1.a,2.k,3.d
	• HF Surface Wave Radar & Line of Sight Radar	5.a
	• Land Mine Detection	2.m
	• EO Atmospheric Propagation	1.a,2.k,3.d
	• Surveillance from Space Based & High Altitude Platforms	3.d,5.e
Conventional Weapons Technology	• Terminal Effects	1.a,2.n,3.e
	• Launch & Flight Dynamics	1.a,2.n,3.e
	• Energetic Materials & Propulsion Technology	2.n
	• Guidance, Control & Fuzing Technology	1.a,2.n,3.e
	• Survivability/Weapons Systems for Ship Point Defence	1.a
	• Non-Lethal Weapons	2.c,2.m.2,n
	• Weapon Systems for Small Unit Operations	2.c,2.n
	• Mine Disposal Technologies (Land)	2.m

NATO Research and Technology Organization

Panel	Technical Teams	Affected Thrusts
Studies, Analysis & Simulation	• Maritime Mine Warfare/Mine Countermeasures	1.d
	• Anti-Submarine Warfare	1.c
	• Alternatives to Anti-Personnel Land Mines	2.m
	• Chemical & Biological Defence	6.q
	• Analysis of Military Effectiveness of Future C2 Concepts & Systems	1.b,2.k,3.a

Prominent International Activities continued

Systems Concepts & Integration	• Physical Characteristics of Targets & Backgrounds	2.k,3.d
	• Camouflage, Concealment & Deception (3 Teams)	2.c,2.f
	• Tactical Implications of High Power Microwaves	1.a,3.e
	• Communications EW Control & Co-ordination	1.a,2.k,3.c
	• Engineer Corps Technologies/Countermining	2.m
	• Vehicle Dynamics, System Identification, Control & Handling	1.g,3.g
	• Flight Test Technology	3.g
	• Co-ordinated EW & Hard Kill C2 for Anti-Ship Missile Defence	1.a
	• Countermeasures to Imaging Radars	1.a
	• Countermeasures to Future EO Guided Threats	1.a,2.f,3.c
	• Anti-Fratricide Measures in Mission Management	1.a,2.k,3.c
Sensors & Electronics Technology	• Electromagnetic Compatibility in Aerospace Systems	3.c
	• Laser Technology for Military Applications	1.a,2.k,3.d
	• Multisensor Image Exploitation	1.a,2.k,3.d
	• Radar Signature in Littoral Environment	1.a
	• Infra-red Measurements & Modelling for Ship Self Defence	1.a
	• Missile & Aircraft EO Signature Modelling	1.a,3.e
	• System Level Sensor Fusion for Land Surveillance	2.k
	• Space-based Observation Technology	5.e
	• Synthetic Data Bases for Non Cooperative Air Target Recognition by Radar	3.d,3.e
Information Systems Technology	• Information Assurance	5.c
	• Multilingual Interoperability of Speech Technology	5.c
	• Visualizing Massive Military Datasets	5.a,6.k
	• Information Fusion	1.b,2.k,3.a,5.a
Applied Vehicle Technology	• Ice Accretion Simulation	3.g
	• Performance Prediction & Simulation of Gas Turbine Engine Operation	3.g
	• Design Loads for Future Aircraft	3.g
	• Ageing Systems Improvement	3.g
	• Enhancing Air Vehicle Inspection Reliability	3.g
	• Shared Test & Qualification of Advanced Paint Removal Technology	1.g,3.g
	• Propulsion Systems for Land, Sea, Air & Space	1.g,3.g
Human Factors & Medicine	• Impulse Noise	2.c,3.f
	• Behind Armour Blunt Trauma	2.n
	• Prophylaxis & Therapy against Chemical Agents	6.q
	• Soldier Mobility: Innovations in Load Carriage Systems	2.c 6.q
	• Radiation Injury & Medical Countermeasures	6.q
	• Protection against Adverse Effects of Toxic Hazards	6.q



Prominent International Activities continued

Bilateral Agreements

Nation	Examples of Current Collaboration
UK	• integrated protective clothing, energetic thermoplastic elastomers, low frequency active sonar, EO protection measures, wide-band HF communications
US	• panospheric imaging for unmanned systems, distributed mission training technologies, hard chrome alternatives for aerospace components, laser pulse propagation in the atmosphere, structural integrity of ageing aircraft
Australia	• sonar signal processing, naval platform engineering, guidance & control of intelligent aerial vehicles, demolition devices technology, ballistic protection & armour materials, undersea warfare decision aids, landmine detection, underwater acoustic materials, vibration isolation materials for naval vessels
Netherlands	• missile propulsion technologies, command & control, terminal ballistics, sonar, smart armour protection, air target classification, defensive information operations, defence against CB warfare agents, environmental effects on EO system performance in the maritime environment, human factors, modelling team performance
France	• inspection & repair of structural composites, NBC defence, pyrophoric decoy flares, distributed artificial intelligence, electromagnetic propagation over the sea, countermine, evaluation of high energy low vulnerability propellants, soldier ballistic protection – anti-trauma aspect, soldier systems modernization
Sweden	• electromagnetic surveillance & silencing, non-nuclear electromagnetic pulses, high power microwaves, low-level radiation, CB defence

Table 12 – Scientific Awards and Honours

- Federal Partners in Technology Transfer Award (June 1999)
  Dave Eaton and Ron Nishi of DCIEM for diving life support technology.

- Technology in Government Week – Gold Medal
  Robert Charpentier, Clement L'Heureux and Michel Patry of DREV in the category of Improvement of Government Operations.

- Chemical Society of Canada – Environment Improvement Award (May 1999)
  John McAndless of DRES.

- AsMA Eric Liljencrantz Award
  William Fraser of DCIEM for excellence in research on aircraft issues in acceleration, altitude and life support equipment.

- The Technical Cooperation Program Achievement Awards
  - ***Calvin Hyatt of DREA for contributions to the Technical Panel on Metals Technology and Performance.***
  - ***John Slater and Gerry Rude of DRES and Grant McIntosh of DREV for contributions to the Technical Panel on Terminal Effects of Conventional Weapons.***
  - ***Gabriel Otis of DREV for contributions to the Action Group on Wide-Area Surveillance/Recognized Picture.***
  - ***Thomas McLellan of DCIEM for contributions to the Technical Panel on Physiological Aspects of Personnel Using Protective Clothing.***

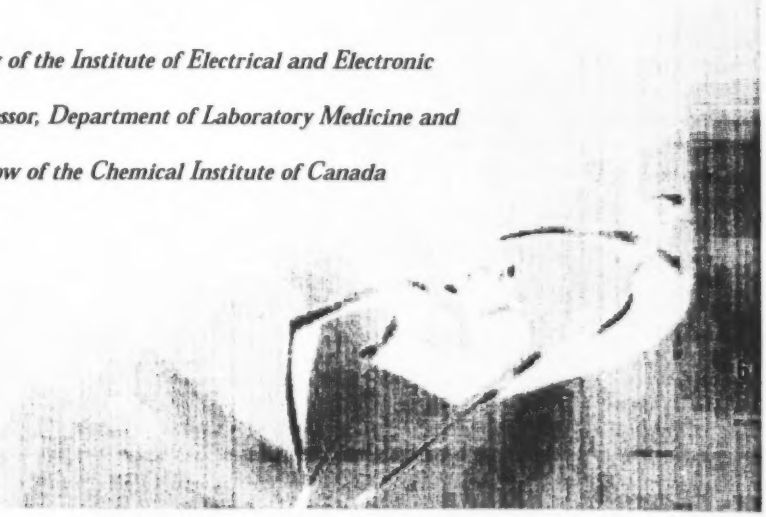
- Best Paper Awards
  - ***Shawn Rhind and Pang Shek of DCIEM, 3rd Annual Meeting on Advances in Laboratory Medicine, 1999.***

- Journal of Atmospheric and Oceanics Technology – Editor's Award
  Luc Bissonette of DREV.

- GEOMATICA Journal – INTERMAP Award
  Francois Letourneau of DREV.

- IEEE Computer Journal – recognition for dedication, quality and expertise in reviewing articles
  Zakaria Maamar of DREV.

- Learned Societies and Universities
  - ***Yogadhish Das of DRES elected Fellow of the Institute of Electrical and Electronic Engineers***
  - ***Pang Shek of DCIEM appointed Professor, Department of Laboratory Medicine and Pathobiology, University of Toronto***
  - ***Peter Lockwood of DREO elected Fellow of the Chemical Institute of Canada***



Annex A

PROGRAM ELEMENTS

The R&D program consists of a number of elements, including: Technology Investigation (TI) and Technology Application (TA) activities, the Technology Demonstration Program (TDP), the Technology Investment Fund (TIF), the Defence Industrial Research (DIR) Program, the DND/NSERC* Research Program and the Defence Communications Program.

*NSERC stands for the Natural Sciences and Engineering Research Council.

Technology Investigation and Technology Application

R&D with a longer time line, because it is earlier in the R&D process, is labelled Technology Investigation, while that responding to an immediate requirement is labelled Technology Application. Almost all these activities are conducted by the DREs through in-house and contracted-out R&D. New TI and TA projects are initiated by the Thrust Advisory Groups and staffed through the annual program formulation process, culminating in an approved Service Level Agreement.

Technology Demonstration Program

The objective of the TDP is to demonstrate technologies fostered by DRDC and Canadian industry in the context of real and potential future CF capabilities, concepts, doctrine, operations, and equipment. The TDP is aimed at concept development and evaluation for force design purposes and is therefore typically not focused uniquely on hardware development. TDP projects are typically 3 to 4 years in duration and have an average "cash" value of $5M. The nominal annual "cash" value of the TDP is $30M. In-kind or cash contributions of the DREs, CF, and industrial or international partners will increase the total value of the project by 50% to 100%. The projects are necessarily fast paced to ensure relevance of the program results and access to state-of-the-art concepts for operational deployment.

Technology Investment Fund

The Technology Investment Fund was established exclusively for the funding of forward-looking, high-risk, but potentially high-payoff, research projects that are consistent with the defence technology investment strategy. The nominal annual "cash" value of the TIF program is $6M. In steady-state operation, approximately one-third of TIF funds will be available for new starts each year. Individual TIF projects will typically not exceed three years in duration and $1M in contracting funds. TIF projects are initiated by individual scientists in the DREs and staffed through the DRE management to the Agency's Technology Assessment Working Group for recommendation to the R&D Executive Committee for approval.

Defence Industrial Research Program

The DIR Program is a cost-sharing industrial program approved by Treasury Board to promote and improve the research and technological capabilities of Canadian defence industry in order to strengthen the defence industrial base. Under this program, defence R&D activities are funded jointly (usually 50/50) by DRDC and Canadian industry. The DIR program is approved to a nominal annual funding level of $4M. DIR Projects are initiated by industry and are staffed through and approved by the Defence Industrial Research Advisory Committee. The projects require formal sponsorship by both the CF and the Agency.

DND/NSERC Research Program

The DND/NSERC Research Program is a jointly managed and jointly funded program which supports university-based research, research training and research-related activities carried out on both a bilateral (DND/university) and multilateral (DND-university-industry) collaborative basis. Preference is given to the latter.

Defence Communications Program

The Agency conducts its program of R&D in communications through an annual allocation of about $3M to the Communications Research Centre.